

March 18, 1952

T. B. DUNN

2,589,606

FORMATION AND CASING TESTER

Filed March 4, 1949

3 Sheets-Sheet 1

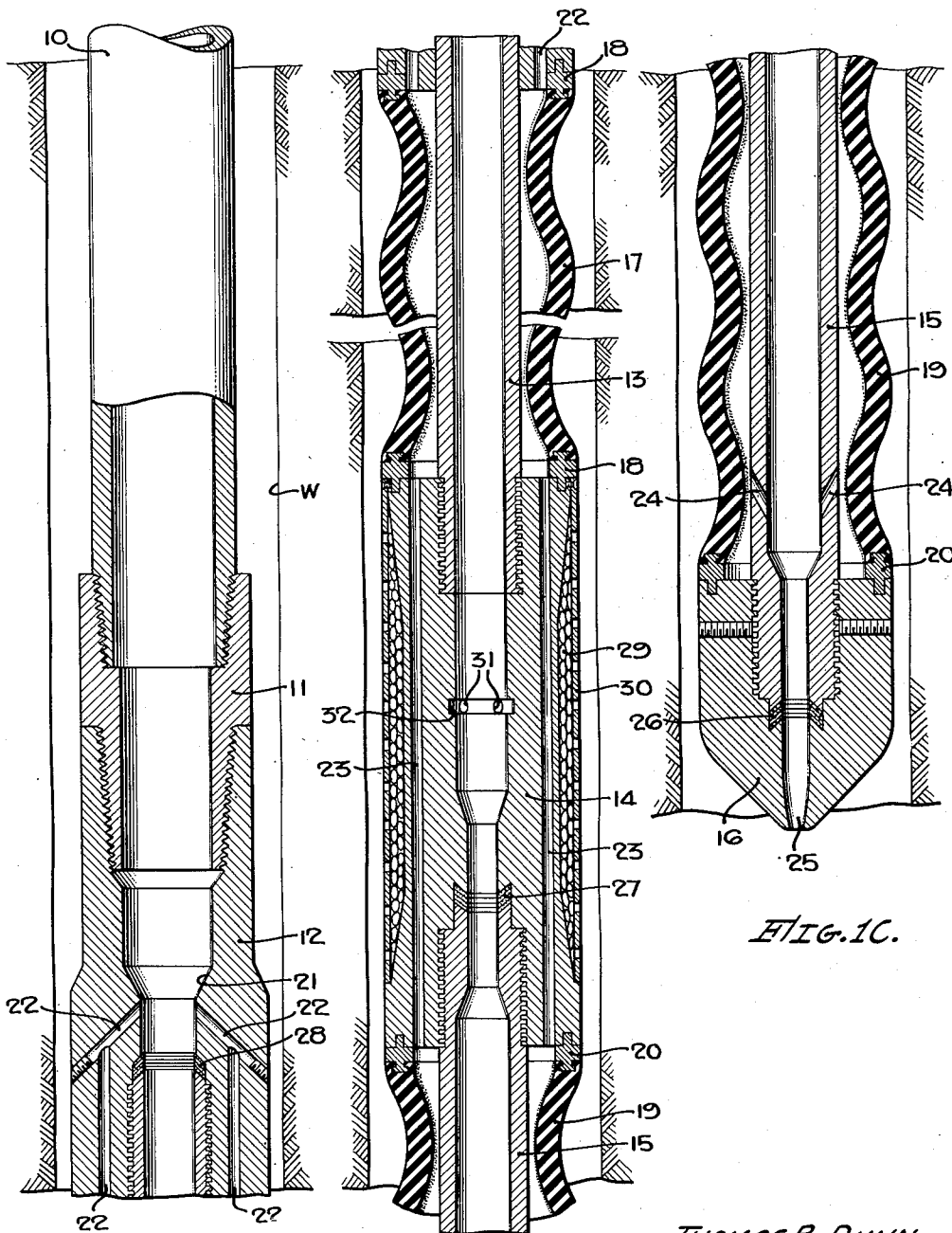


FIG. 1A.

FIG. 1B.

FIG. 1C.

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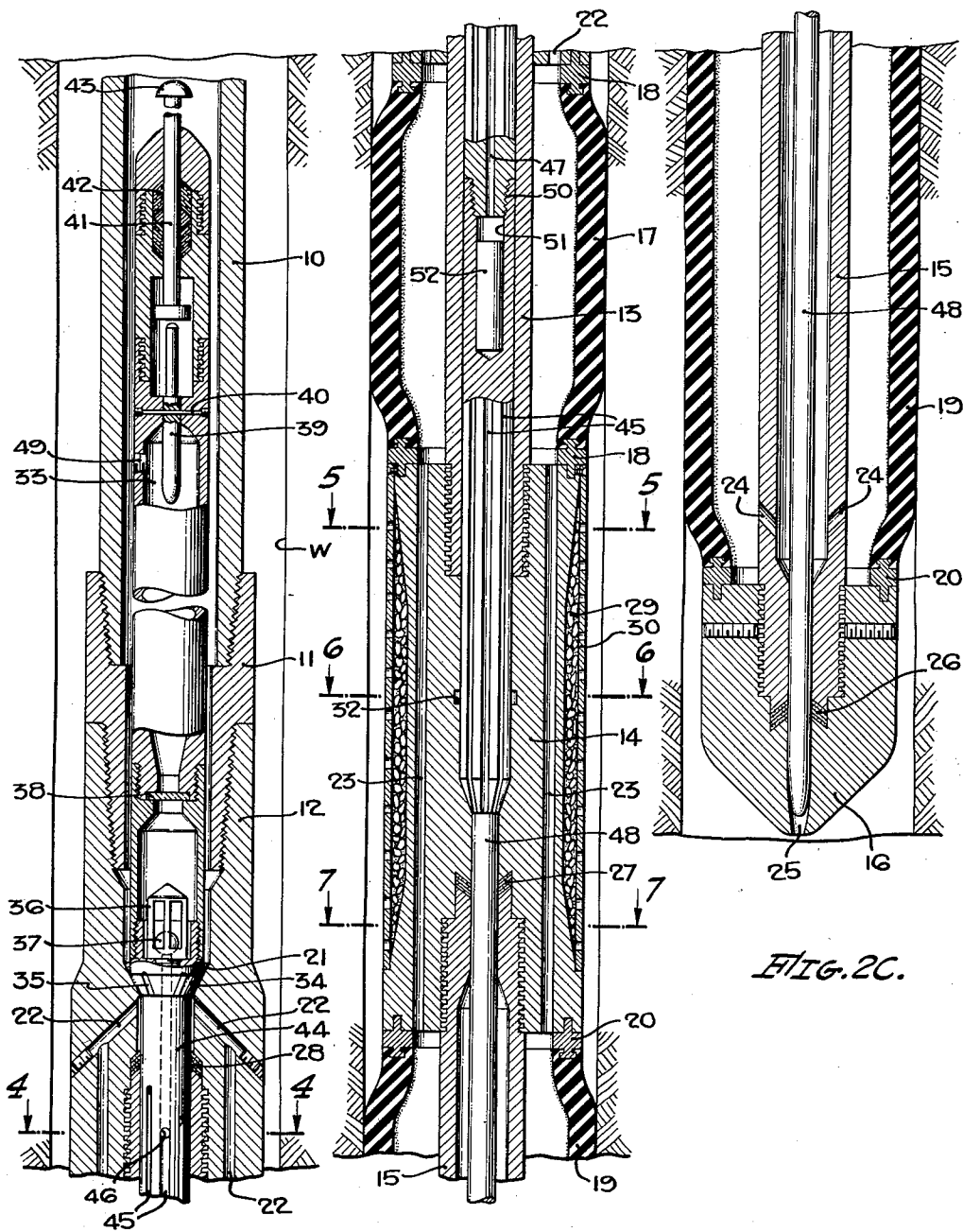
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

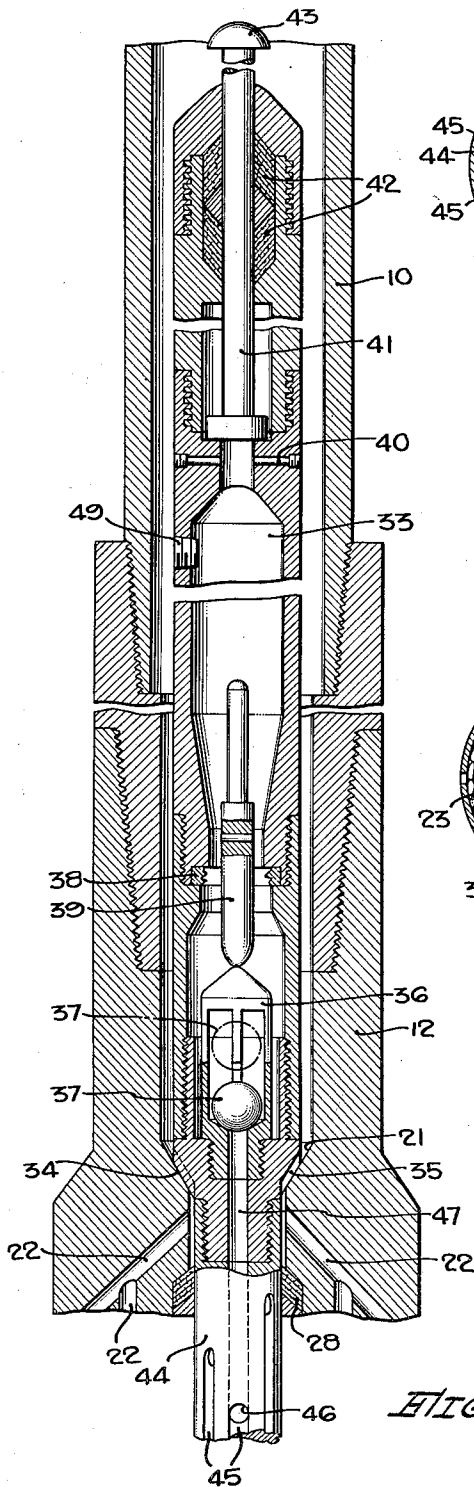


FIG. 3.

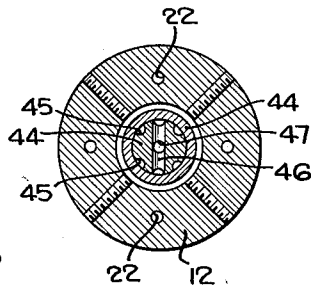


FIG. 4.

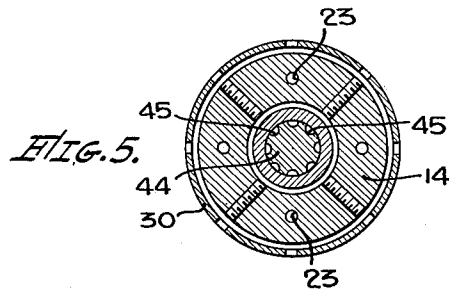


FIG. 5.

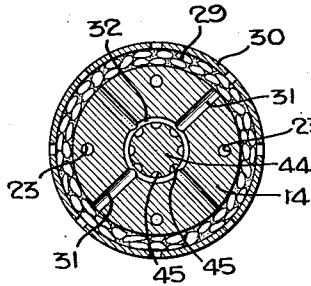


FIG. 6.

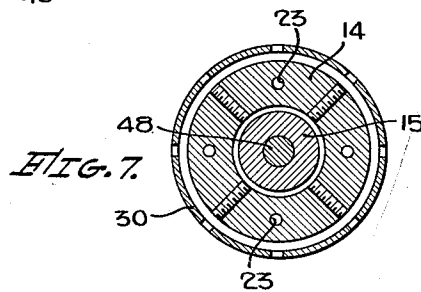


FIG. 7.

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FORMATION AND CASING TESTER

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Application March 4, 1949, Serial No. 79,583

6 Claims. (Cl. 166—1)

1

This invention relates to a method and apparatus for testing formations and casings in wells, such as oil wells.

Heretofore, formation testers have been provided for testing formations penetrated by wells which employ packers which serve to temporarily isolate the upper portion of the well from the lower portion thereof. In some instances, shoulders or seats are formed on the walls of the well on which such packers may be seated to thus isolate the upper portion of the well from the bottom. In other instances, cylindrical packers have been employed which can be seated or expanded by pressing some part of the apparatus against the bottom of the well. The formation testers heretofore provided have universally employed but a single packer so that it is only possible to isolate that portion of the well above the packer from that portion of the well which is below the packer.

It frequently occurs, however, that a single well will penetrate two or more productive strata and that it is desirable to test the production from each stratum independently of the other strata that may also be penetrated by the well. The formation testers heretofore devised can of course isolate the lowermost stratum from those thereabove and the lowermost stratum can be tested independently of upper strata. However, when it is desired to test upper strata or an upper stratum the formation testers heretofore devised could only make such a test in combination with the lowermost stratum or all strata therebelow. Consequently, the productivity of any upper stratum independent of other strata penetrated by the well could not be accurately ascertained.

It is an object of the present invention to provide a method and apparatus whereby any stratum or group of strata penetrated by the well can be isolated from the remainder and tested for productivity. The method and apparatus may also be advantageously employed for testing casing in that any portion of the casing can be isolated from the remainder and accurately tested.

Another object of the invention is to provide a formation and casing tester consisting essentially of a body adapted to be lowered into a well by a run-in string of pipe and which has vertically spaced, hydraulically expansible packers thereon adapted to receive fluid pressure from the interior of the run-in string of pipe so as to be expanded thereby and which are so designed that whenever occasion requires the interiors of the packers may be flushed out so as to wash out sediment tending to deposit therein and enabling the packers to be

2

collapsed at the conclusion of a test so that the tool can be readily recovered or shifted to a new location for a further test.

Another object of the invention is to provide a formation and casing tester consisting of a body having vertically spaced packers thereon and wherein ingress is provided from the exterior of the tool between the packers and wherein a fluid-receiving chamber is adapted to seat on the body and establish communication with the ingress-providing means so as to receive a fluid sample from the well between the packers, and to provide means for entrapping the fluid sample therein. The chamber which receives the fluid sample is removable or recoverable from the well independently of the body of the apparatus enabling one fluid-receiving chamber after another to be seated on the tool to receive test samples either at the same location or setting of the tool or at different locations or settings. In this manner, a series of productive strata can be consecutively tested without involving a withdrawal of the body of the apparatus from the well between tests.

With the foregoing and other objects in view, which will be made manifest in the following detailed description and specifically pointed out in the appended claims, reference is had to the accompanying drawings for an illustrative embodiment of the invention, wherein:

Figures 1A, 1B, and 1C are vertical sections through the top, middle portion, and bottom of the body of the tool embodying the present invention;

Figs. 2A, 2B, and 2C are similar views, but illustrating the fluid-receiving chamber providing means as having been seated on the body;

Fig. 3 is a sectional view on a somewhat enlarged scale of that portion of the tool illustrated in Fig. 2A, but showing the fluid-receiving chamber as having been opened for the reception of sample fluid that may enter from between the vertically spaced packers;

Fig. 4 is a horizontal section taken substantially upon the line 4—4 upon Fig. 2A; and

Figs. 5, 6, and 7 are horizontal sections taken substantially upon the line 5—5, 6—6, and 7—7, respectively, upon Fig. 2B.

Referring to the accompanying drawings wherein similar reference characters designate similar parts throughout, 10 indicates a run-in string of pipe such as tubing or drill pipe by which the body of the tool can be lowered into the well W. On the lower end of this string of pipe there is mounted a sub 11 to which is attached an upper body part 12. A section of tub-

3

ing 13 connects this upper body part to a central body part indicated at 14 and in a similar manner a lower section of tubing 15 connects the central body part to the bottom or lowermost body part 16, thus forming a body on which two vertically spaced, hydraulically expansible packers are mounted.

The upper packer 17 consists of a sleeve of expansible flexible rubber anchored at its top and bottom by means of anchoring fittings 18, flanges of which may be molded directly into the ends of the sleeve. In a similar manner the lower packer consists of a flexible expansible rubber sleeve 19 anchored at its top and bottom by means of fittings 20. In the upper body part 12 there is formed a tapered seat 21 and immediately below this seat there are passages 22 leading from the interior of the upper body part to the interior of the upper packer sleeve 17. Vertical bores 23 are formed in the central body part 14 and provide communication between the lower end of the upper packer 17 and the upper end of the lower packer 19. An outlet from the lower packer 19 is provided by means of passages 24 which provide communication between the lower end of the lower packer 19 and the interior of the tubing 15. The interior of the tubing 15 communicates with a central bore or passage 25 in the lower body part 16 around which packing 26 is provided. In a similar manner packing 27 is arranged between the upper end of tubing 15 and the central body part 14 and packing 28 is arranged between the top of tubing 13 and the upper body part 12. With this arrangement it will be appreciated that on closing the outlets 24 and forcing fluid under pressure, such as circulation fluid, into the passages 22 that the packers 17 and 19 will both be expanded into engagement with the well walls. Conversely, on opening the outlets 24 any sediment which tends to settle from the circulation fluid within the packers can be flushed out of the outlets to allow the packers to contract in shifting the tool within the well or withdrawing it therefrom.

The exterior of the central body part 14 is preferably reduced to accommodate a gravel pack 29 which is confined thereabout such as by a perforated sleeve 30. The gravel pack is arranged about a series of radial apertures 31, see Fig. 6, which are arranged between the bores 23 and which communicate at their inner ends with a horizontal annular groove 32. These radial passages provide a means of ingress for fluid to the interior of the body from the exterior thereof between the packers 17 and 19.

As a means for receiving, entrapping, and recovering the fluid which enters the body from between the packers, there is provided a chamber indicated at 33. This chamber may be made up of sections of pipe or tubing of any suitable length to provide adequate volumetric capacity to receive the desired amount of sample. This chamber has a tapered seating surface 34 formed thereon adapted to seat upon the tapered seat 21. In this seating surface grooves 35 are formed so that even though the chamber may be seated on the seat 21 fluid pressure within the run-in string of pipe can be conducted through the grooves 35 to the passages 22 to expand the packers. Adjacent the seating surface 34 there is mounted a cage 36 for an upwardly opening, downwardly closing ball check valve 37 and above this check valve the chamber is sealed by a frangible disc 38 such as a glass disc. In the top of the chamber there is releasably supported a

4

go-devil 39 which is held in position by means of a shear pin 40. This go-devil can be released by being forced downwardly with sufficient force to shear the shear pin 40. Such a force may be applied by means of a rod 41 that slidably extends through the top of the chamber and through packing 42 therein. This rod preferably has a head 43 which can be forced downwardly by means of a socket to release the go-devil 39 and which also enables the socket to engage therewith to recover the chamber 33 from the well. Below the seating surface 34 there is secured to the chamber a stem 44. This stem is designed to enter the tubing 13 rather closely so as to effect a seal thereabouts by means of the packing or sealing means 28. The stem is externally grooved as at 45 throughout a major portion of its length and the upper ends of these grooves communicate with diametrical bores 46 which in turn communicate with a vertical bore 47 leading to the underside of the ball check valve 37. The diametrical bores 46 are preferably arranged at different elevations along the stem 44 so that the stem will not be unnecessarily weakened at any particular locality. The lower end of the stem is reduced as at 48 and is designed to enter and form close seals with the packing at 27 and 26 as shown on Figs. 2B and 2C.

The operation of the above described apparatus is substantially as follows:

The body of the device, together with its associated packers 17 and 19 is lowered by means of the run-in string of pipe 10 to the desired elevation in the well. The spacing of the packers 17 and 19 is such as to have disposed therebetween the stratum of the formation that it is desired to test. This spacing may be increased or decreased as occasion may require by substituting longer or shorter central body parts 14 for the body part shown. When the body of the tool has been thus positioned the inner barrel or chamber-providing means 33 is dropped or lowered inside of the run-in string of pipe and upon seating itself on the seat 21 it will be observed that the contracted lower end of the stem 48 will effectively close the outlets 24 by reason of its engagement with the packing or seals 26 and 27. A wire line with a conventional socket on its lower end is then started in the run-in string of pipe 10 and the wire line is then packed off so that pressure can be supplied to the inside of the run-in string 10. The pressure, on being applied, is effective through the grooves 35 and the passages 22 and 23 to expand or inflate the sleeves of the packers into well wall-engaging position as shown on Fig. 2B. In this manner, that portion of the well which is between the packers is in effect isolated from that portion of the well which is above the upper packer 17 and it is also isolated from that portion of the well which is below the lower packer 19. Fluid in the stratum to be tested can then enter the body through the perforations in the sleeve 30, the gravel pack 29, and radial bores 31 without being contaminated by fluids entering the well above or below the two packers. When both packers have been thus expanded into engagement with the well walls, the wire line with its attached socket is lowered in the run-in string of pipe. The socket will take hold of the head 43 but the weight of the socket or socket and sinker bar, if a sinker bar is necessary, can be used to force the rod 41 downwardly to engage the go-devil 39 and shear the shear pin 40. When the shear pin 40 is sheared the go-devil is re-

5

leased and may drop through the chamber 33 until it encounters and breaks the frangible or glass disc 38. As the pressure within the chamber 33 initially only is atmospheric pressure, the breaking of the disc 38 in effect breaks the seal of the chamber and allows well fluid entering the body from between the packers to flow upwardly through the grooves 45 inwardly through the radial bores 46, upwardly past the check valve 37 and into the chamber. When the chamber has been filled the inner barrel can be withdrawn from the well by means of the wire line and socket which has engaged the head 43. The check valve 37 functions as an entrapping valve entrapping the sample within the chamber. The withdrawal of the inner barrel or chamber-providing means also involves a withdrawal of the reduced portion of the stem 48 which on withdrawal again opens the outlets 24. This permits the packers to contract. After the inner barrel is thus recovered the run-in string of pipe can also be withdrawn from the well, thus recovering the body of the tool.

While in the usual circumstance it is adequate to merely have the chamber 33 filled with air at atmospheric pressure, if desired a vacuum may be pumped in this chamber prior to its being introduced into the well and to this end the chamber is illustrated as being provided with a fitting 49 through which the chamber 33 can be completely exhausted and sealed prior to its introduction into the well.

If sediment has collected in either or both of the sleeves 17 and 19 so as to retard or prevent contraction of these sleeves a dummy chamber may be lowered into the well and seated on the seating surface 21. This dummy chamber may have a stem 44 but the stem should terminate well above the seal 26 so as to leave the ports 24 open. While in this condition circulation fluid can be pumped into the run-in string of pipe 10 and caused to flow downwardly through the two packers, thus flushing out the sediment through the outlets 24.

It will be appreciated that if it is desired to test several strata separately that it is unnecessary to withdraw the body of the tool from the well. This may be shifted in the well from one location to another and the inner barrel consecutively run in the run-in string of pipe seated, opened, and recovered, thus, obtaining samples from each formation that is isolated from the remainder of the well by the two packers.

It is frequently desirable to ascertain the formation pressure existing in the stratum that is being tested for the purpose of determining whether or not that stratum is what is commonly referred to as a "thief sand." Thus, in some wells a stratum may be penetrated by the well hole wherein the formation pressure is so low with relation to adjoining strata that oil and/or gas produced from the adjoining strata escapes through the "thief sand" instead of being recovered through the well hole. To this end the bore 47 in the stem 44 is preferably continued downwardly below the diametrical bores 46 in the stem and the stem is preferably divided into two sections connected by threads indicated at 50. Below this joint in the stem the bore 47 is enlarged as at 51 to receive a bottom hole pressure measuring and recording instrument indicated at 52. These bottom hole pressure recording devices are well known and the details of their construction form no part of the present invention and the instrument 52 is consequently not illustrated in detail herein.

6

When such a pressure recording instrument is used during the descent of the inner barrel through the run-in string of pipe the pressure recording instrument will record a gradual and continuous increase in the static pressure until the inner barrel is seated on the seat 21. The pressure will be conducted to the chamber 51 through the diametrical bores 46 and the vertical bore 47. At the time that the go-devil 39 is released to fracture the glass disc 38, there will be a sudden drop in pressure due to the opening of the low pressure chamber 33 and this drop will be recorded on the bottom hole pressure measuring instrument. However, as the pressure in the stratum being tested causes fluid to enter the chamber 33, pressure in this chamber will gradually build up again and be recorded to indicate what the formation pressure is in the stratum tested. When the sample is completely obtained and the inner barrel is withdrawn, the pressure then conducted to the chamber 51 will be the static pressure in the well at or near the seat 21. Consequently, by eliminating from consideration the increase in static pressure as the inner barrel descends in the well and the decrease in the static pressure as the inner barrel is recovered from the well, the formation pressure in the stratum tested can be ascertained.

From the above-described construction it will be appreciated that a new method and apparatus is provided for isolating any portion of a well from the remainder of the well thereabove and from the remainder of the well therebelow and obtaining a test sample of fluid from the isolated portion. In addition to obtaining a test sample of fluid from the isolated portion of the well it is possible to also determine the formation pressure of such isolated portion, and in this way determine whether or not there exists a "thief sand."

While the construction has been described as being used to test one or more strata penetrated by the well it will be appreciated that it may also be advantageously employed in testing casing.

Various changes may be made in the details of construction without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A flow tester comprising a body adapted to be positioned in a well having vertically spaced packers thereon, means providing for ingress of well fluid from between the packers to the interior of the body, a seat on the body, a fluid receiving chamber adapted to seat upon said seat and having means for forming a fluid-receiving connection with the ingress-providing means, an upwardly opening, downwardly closing check valve in the lower end of the chamber, a breakable disc thereabove, a go-devil releasably suspended in the chamber adapted upon release to break the disc and thus allow fluid in the well between the packers to enter the chamber past the check valve, and means for effecting a release of the go-devil.

2. A flow tester comprising a body adapted to be positioned in a well by a run-in string of pipe, a pair of vertically spaced packers on the body, the body having passages communicating with the interior thereof and with the exterior thereof at points located between the packers so as to receive well fluid from between the packers, the body having other passages communicating at their upper ends with the interior of the body at points above the first-named passages to re-

ceive drilling fluid from the run-in string of pipe and communicating with the interiors of the packers and communicating at their lower ends with the interior of the body at a point below the first-named passages, and means adapted to be lowered through the run-in string of pipe and into the body and forming a seal with the body at a point between the first-named passages and the upper ends of the second-named passages and a seal at a point between the first-named passages and the lower ends of the second-named passages and receiving well fluid from the first-named passages without contamination.

3. A flow tester comprising a body adapted to be positioned in a well by a run-in string of pipe, a pair of vertically spaced packers on the body, the body having passages communicating with the interior thereof and with the exterior thereof at points located between the packers so as to receive well fluid from between the packers, the body having other passages communicating at their upper ends with the interior of the body at points above the first-named passages to receive drilling fluid from the run-in string of pipe and communicating with the interiors of the packers and communicating at their lower ends with the interior of the body at a point below the first-named passages, means adapted to be lowered through the run-in string of pipe and into the body and forming a seal with the body at a point between the first-named passages and the upper ends of the second-named passages and a seal at a point between the first-named passages and the lower ends of the second-named passages and receiving well fluid from the first-named passages without contamination, means for communicating the interior of the body with the exterior thereof at a point below the lowermost packer to enable drilling fluid to flow from the packers out of the body, and means for closing the last-named means to enable the packers to be expanded.

4. A flow tester comprising a body having a longitudinal passage therethrough and adapted to be positioned in a well by a run-in string of pipe, a pair of vertically spaced packers on the body, the body having passages communicating with the interior thereof and with the exterior thereof at points located between the packers so as to receive well fluid from between the packers, the body having other passages communicating at their upper ends with the interior of the body at points above the first-named passages to receive drilling fluid from the run-in string of pipe and communicating with the interiors of the packers and communicating at their lower ends with the interior of the body at a point below the first-named passages, means adapted to be lowered through the run-in string of pipe and into the body forming a seal with the body at a point between the first-named passages and the upper ends of the second-named passages and a seal at a point between the first-named passages and the lower ends of the second-named passages and receiving well fluid from the first-named

passages without contamination, and means for closing the lower end of the body to enable drilling fluid to expand the packers into engagement with the walls of the well.

5. A flow tester comprising a body adapted to be positioned in a well by a run-in string of pipe, a pair of vertically spaced packers on the body, the body having passages communicating with the interior thereof and with the exterior thereof at points located between the packers so as to receive well fluid from between the packers, the body having other passages communicating at their upper ends with the interior of the body at points above the first-named passages to receive drilling fluid from the run-in string of pipe and communicating with the interiors of the packers for conducting well fluid to the packers for expanding the same, means for connecting the interiors of the packers with the exterior of the body at a point outside the packers, means adapted to be lowered through the run-in string of pipe and into the body and forming a seal with the body at a point between the first-named passages and the upper ends of said other passages and receiving well fluid from the first-named passages without contamination, and a valve element carried by the last-named means for closing the connecting means to enable the packers to be expanded.

6. A flow tester comprising a body adapted to be positioned in a well by a run-in string of pipe, a pair of vertically spaced packers on the body, means establishing communication between the interiors of the packers and the run-in string of pipe so that the packers may be expanded by pressure supplied to the run-in string of pipe, means providing for ingress of well fluid from between the packers to the interior of the body, a seat on the body, a fluid-receiving chamber adapted to seat upon said seat and having means for forming a fluid-receiving connection with the ingress-providing means, an upwardly opening, downwardly closing check valve in the lower end of the chamber, a breakable disc thereabove, a go-devil releasably suspended in the chamber adapted upon release to break the disc and thus allow fluid in the well between the packers to enter the chamber past the check valve, and means for effecting a release of the go-devil.

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