

June 7, 1960

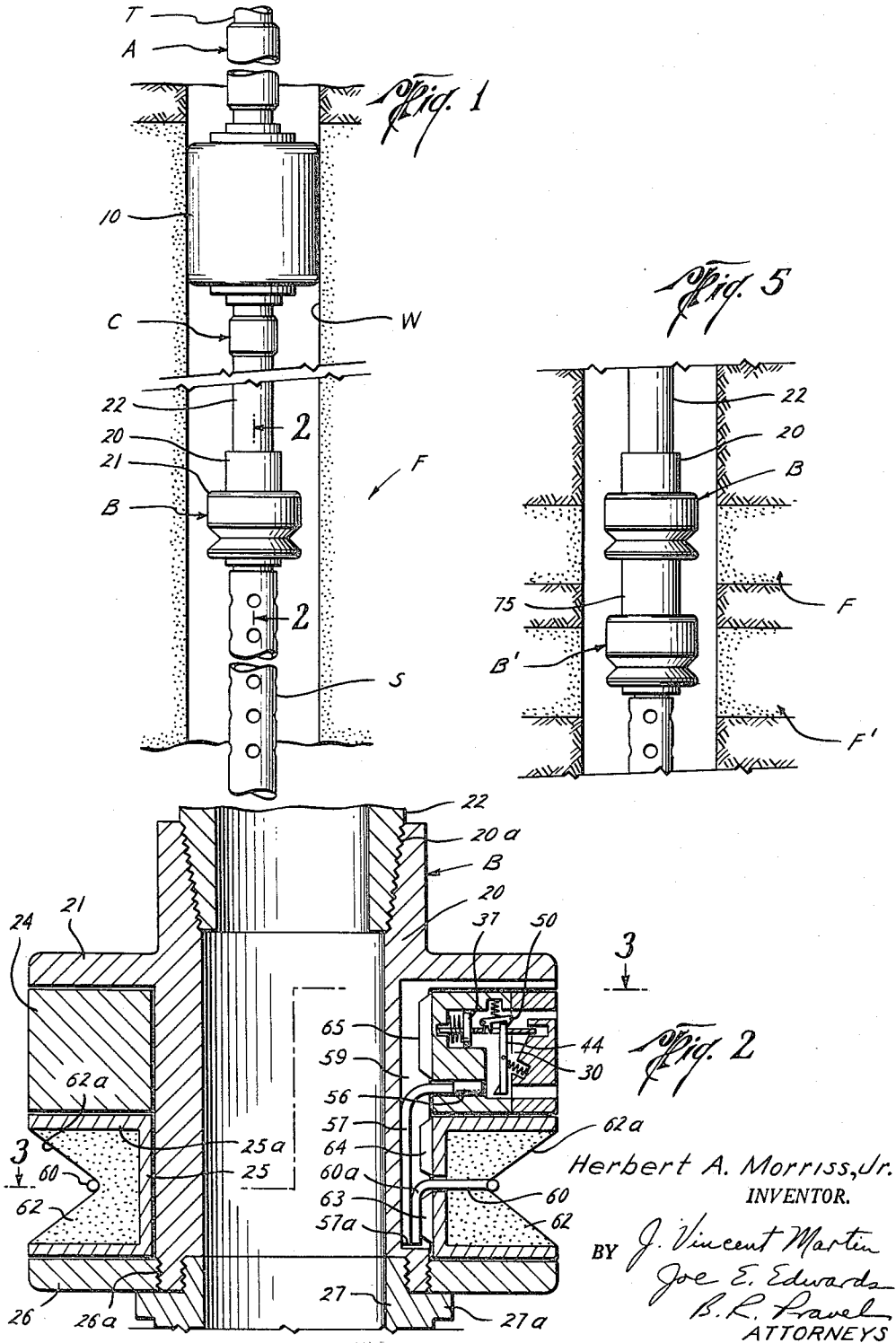
H. A. MORRISS, JR

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WELL APPARATUS FOR WELL FORMATION TESTING

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2 Sheets-Sheet 1



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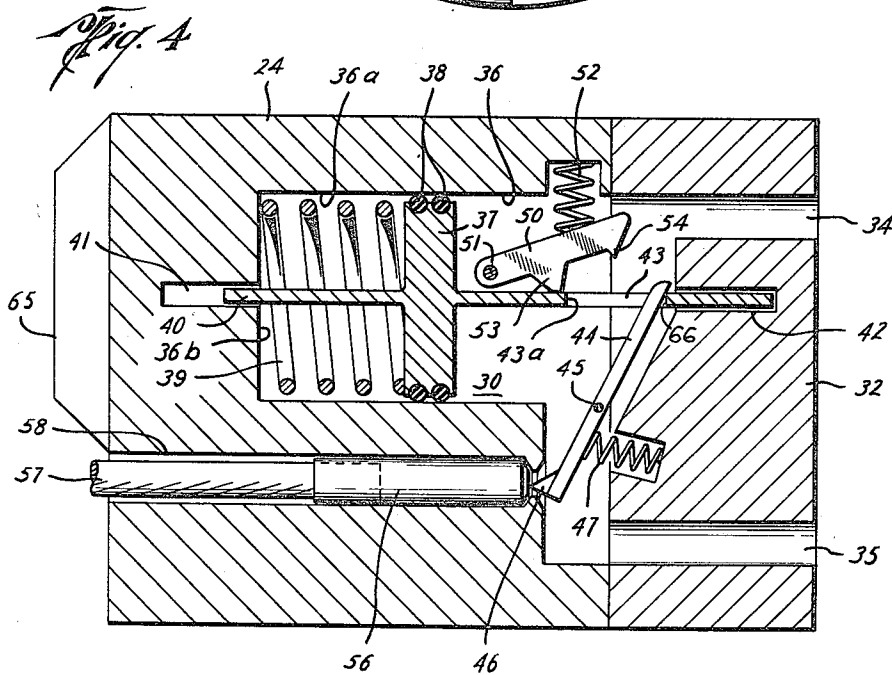
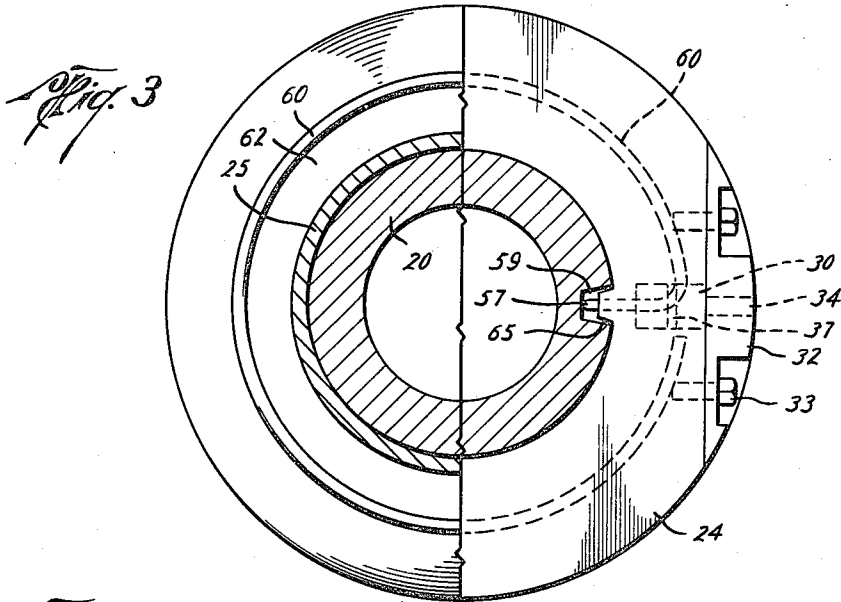
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## WELL APPARATUS FOR WELL FORMATION TESTING

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This invention relates to new and useful improvements in apparatus for well formation testing.

It is an object of this invention to provide a new and improved apparatus for effectively cleaning the wall of a well bore adjacent a well formation to facilitate the obtaining of a fluid sample from the well formation.

An important object of this invention is to provide a new and improved apparatus for obtaining a fluid sample from a well formation in a well bore wherein the wall of the well bore adjacent said well formation is cleaned substantially simultaneously with the taking of the fluid sample, such cleaning of the wall of the well bore being preferably carried out by blasting the wall with an explosive charge.

Another object of this invention is to provide a new and improved apparatus for use in a well bore wherein the fluid pressure in the well bore is reduced upon the opening of a valve in a conventional formation tester device, such fluid pressure reduction effecting a detonation of an explosive charge for cleaning the wall of the well bore adjacent the well formation to be tested whereby the cleaning of the wall of the well formation and the taking of the sample with the formation tester is substantially simultaneous which prevents a mud cake from forming on the wall of the formation prior to the obtaining of the formation test sample.

A further object of this invention is to provide a new and improved perforator apparatus for use in a well bore for perforating the wall of a well formation therein, wherein the perforating apparatus is so constructed that it is incapable of firing the explosive charge until the device is lowered into the well bore and the fluid pressure in the well has been reduced below a predetermined amount.

Still another object of this invention is to provide a new and improved formation perforator apparatus wherein the fluid pressure of the well is initially utilized to arm the firing mechanism upon insertion of the apparatus into a well bore.

The construction designed to carry out the invention will be hereinafter described, together with other features thereof.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

Figure 1 is a view, partly in elevation and partly in section, illustrating one form of the apparatus of this invention.

Figure 2 is a sectional view taken on line 2—2 of Figure 1 and illustrating one form of the cleaner unit or device of this invention, with the actuator section in an armed position.

Figure 3 is a horizontal view, partly in plan and partly in section, illustrating the construction of Figure 2 taken on line 3—3 of Figure 2.

Figure 4 is an enlarged sectional view of the detonator

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portion of the cleaner unit or device illustrated in Figure 2, with the actuator section in an unarmed or released position.

Figure 5 is an elevation of a multiple cleaner unit or device.

In the drawings, the letter A designates generally a well formation tester which is of conventional construction and which is connected to a formation perforator or cleaner device B by means of a coupling C or other suitable connecting means. The apparatus, which includes the formation tester A and the cleaner unit or device B, is lowered into a well bore W so as to position the perforator device B adjacent a well formation F from which a sample of the formation fluid is to be obtained for a formation test. The formation tester A has a usual packing element or sealing means 10 which is adapted to engage in sealing contact with the wall of the well bore W above the formation F. A sample of the fluid in the formation F is obtained by the opening of the usual valve (not shown) in the formation tester A and, as will be explained in detail, the cleaner device B is fired substantially simultaneously with the opening of such valve to thereby effect a cleaning or removal of the mud cake from the wall of the well bore substantially simultaneously with the taking of the sample of the formation fluid with the formation tester. Thus, prior to the formation of any new mud cake or other wall cake on the wall of the well bore adjacent the well formation F, the fluid sample from the formation is obtained.

The details of the cleaner device B are illustrated in Figures 2—4. Such device B includes an internal support sleeve 20 which has an upper radially extending flange 21. The upper end of the support sleeve 20 is connected by internal threads 20a or other suitable means to a pipe or tube 22 which in turn is connected with the coupling collar or sleeve C (Figure 1).

An actuator section 24 is disposed below the upper flange 21 and an explosive charge section 25 is disposed below the actuator section 24. A base flange 26 is threaded by threads 26a or other suitable connecting means to the support sleeve 20 for retaining the actuator section 24 and charge section 25 thereabove. The base flange 26 is locked in position by an annular locking sub 27 which is threaded or otherwise suitably connected to the lower end of the support sleeve 20 and which has a radial flange 27a which abuts against the lower side of the base flange 26. The sub 27 is connected to a slotted or perforated pipe S which serves as a strainer or screen in the known manner during the taking of the fluid sample with the formation tester.

The actuator section 24 is in the form of a ring of steel or other similar material and is substantially solid except for an actuator chamber 30 which is formed therein. The chamber 30 is closed by a removable cover plate 32 which is retained in position by a suitable connecting means such as screws 33 (Figure 3). The removable cover plate 32 has laterally extending ports 34 and 35 which are in fluid communication with the actuator chamber 30 (Figure 4).

Within the chamber 30, a cylinder 36 is formed in which a piston 37 is positioned for relative movement therein. The piston 37 has a seal means such as the annular seal rings 38 formed of rubber or other elastic material, mounted thereon to maintain the inner portion 36a of the cylinder 36 sealed off from the rest of the cylinder 36 and the actuator chamber 30, whereby air is confined within the closed cylinder portion 36a. A spring 39 or other resilient means is mounted within the cylinder 36 and is confined between the piston 37 and the inner wall 36b of the cylinder 36. An operating rod 40 extends from the piston 37 with one portion thereof projecting into a guide slot 41 while the other end

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thereof projects into a similar guide slot 42 formed in the cover plate 32, whereby the movement of the piston is guided to prevent tilting of the piston 37 in the cylinder 36. The operating rod 40 has a longitudinal cam slot 43 formed therein through which projects the upper end of a cocking lever 44 which is pivoted at pivot pin 45. A hammer 46 is mounted at the lower end of the cocking lever 44 and such cocking lever 44 is normally urged in a clockwise direction (as viewed in Figure 4) by a hammer spring 47.

Above the operating rod 40 a latch lever 50 is located which is pivoted at pivot pin 51. The latching lever 50 is urged downwardly by latch spring 52, but the downward movement of the latching lever 50 is limited when the operating rod 40 is in the unarmed position (Figure 4) by reason of the contact of a cam 53 with the upper surface of the operating rod 40 (Figure 4). At the outer end of the latching lever 50 is latch 54 which is retained in a raised or released position (Figure 4) when the operating rod 40 is in the unarmed position. Upon a movement of the operating rod 40 to the left (as viewed in Figure 4) to position the rod 40 in an armed position, the cam 53 drops into the opening 43 and the latch 54 engages the upper end of the cocking lever 44 to thereby put the actuator device into an armed position for firing (Figure 2). It is believed evident that the wall 43a is preferably so positioned with respect to the cam 53 that it holds the latch lever 50 in the raised position (Fig. 4) until the upper end of the cocking lever 44 is positioned to the left of the latch 54, but even if the wall 43a is so positioned with respect to the cam 53 so as to permit the cam 53 to drop into the opening 43 prior to the positioning of the upper end of the lever 44 to the left of the latch 54, the lever 44 can still be moved into its latching position to the left of the latch 54 by a camming action of the lever 44 with the right inclined surface of the latch 54 to raise the lever 50 sufficiently for the upper end of the lever 44 to pass to the left of the latch 54, at which time the lever 50 will of course drop by gravity to prevent the return of the lever 44 to the right until such time as the fluid pressure in the chamber 30 is reduced as explained hereinafter. The rod 40 is moved to the left when the fluid pressure in the chamber 30 acts on the piston 37 with a force in excess of the strength of the spring 39. As the piston 37 is moved inwardly the air in the closed portion 36a of the cylinder 36 is compressed. It will also be evident that upon a movement of piston 37 and the operating rod 40 to the right (as viewed in Figure 4) by reason of a reduction in the fluid pressure in the chamber 30, the inner wall 43a of the cam slot 43 engages with the cam 53 to effect a raising of the latch lever 50, whereby the latch 54 is disengaged from the cocking lever 44 so that the hammer spring 47 is then free to urge the hammer 46 into contact with a percussion primer of firing cap 56. The movement of the piston 37 and thus the arming and firing of the actuator device is therefore controlled by well fluid pressure which acts upon the piston 37, as will be explained more in detail hereinafter.

The percussion primer 56 is connected to a primacord detonator 57 which extends from an opening 58 in the actuator ring 24 into a key way 59 formed in the external surface of the support sleeve 20. The lower end 57a of the primacord detonator 57 terminates at the lower end of the keyway 59 and adjacent the inner end of a primacord 60 which extends in an annular ring (Figures 2 and 3) around the annular explosive 62 for the purpose of detonating the explosive 62 upon the firing of the percussion primer 56. The explosive 62 is cast or otherwise formed in the annular grommet shaped steel collar 25a, such explosive being of the pentolite type or of any other common type customarily used in the jet perforating of oil well casing. Preferably, the exposed face of the cast explosive 62 is formed with an acute angle 62a so as to obtain a shaped charge blast in the horizontal plane. For mechanical protection, the face of

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the shaped charge 62 is preferably lined with a plastic (not shown) such as a vinyl resin, the fragments of which do not interfere with the operation of the formation tester A. It will be observed that the detonator lead cord 60 is positioned at the apex of the acute angle 62a of the explosive charge 62. The inner end 60a of the primacord detonator lead 60 is positioned adjacent the lower end 57a of the detonator cord 57 and is compressed into contact therewith by the lower spline or key 63 on the steel ring 25a which extends into the keyway 59 in the support sleeve 20. Similarly spline 64 is formed on the ring 25a and also extends into the keyway 59, but it is narrow enough so that it does not contact the detonator cord 57. Also, the actuator ring 24 has a spline 65 which also extends into the keyway 59. By means of the splines 63, 64 and 65, the actuator ring 24 and the charge ring 25 are both properly aligned with each other during assembly and are maintained in proper alignment during use.

In using the apparatus of this invention, the apparatus illustrated in Figure 1 is lowered into the well bore W on the empty drill pipe T and the formation tester A is positioned in the usual manner so as to place the packing or sealing element 10 in sealing contact with the wall of the well bore at a suitable point above the formation to be tested. The length of the pipe 22 is such that the cleaner device B is positioned adjacent the well formation F which is to be tested. It should be pointed out that during the lowering of the apparatus of Figure 1 into the well bore, the device is being lowered through drilling mud or well fluid which is maintained under a pressure which is sufficient to prevent a flow of fluid from the formation F and any other formation which has been penetrated. The cleaner device B is so constructed for safety purposes that it is not armed for detonation or firing until the apparatus has been lowered into the drilling mud or well fluid. Thus, when the predetermined pressure of the mud or other fluid in the well bore acts upon the cleaner or perforator device B, the device is moved to its armed or cocked position, that is, the position for firing (Figure 2). During the arming or cocking of the actuator section 24 from its unarmed position (Figure 4), the piston 37 is moved to the left by the well fluid pressure which causes a compression of the spring 39 and a compression of the air in the cylinder portion 36a. The cleaning device B is therefore in its armed or cocked position at the time it is located adjacent the well formation F from which the test sample is to be taken.

When it is desired to take the test sample from the formation F, a valve of conventional construction (not shown) within the formation tester A is opened so as to permit fluid flow through the screen S and the bore of the support sleeve 20 and upwardly through the inside of the pipe 22 to the interior of the formation tester A. When such valve in the formation tester A is thus opened, the fluid pressure in the area adjacent the formation F is reduced due to the flow of the fluid from the well bore W upwardly into the formation tester A. Substantially simultaneously with the opening of the valve in the formation tester A, the cleaner device B is detonated or fired because the reduction in the fluid pressure in the well bore which is caused by the opening of the valve in the formation tester A also results in a reduction in the fluid pressure on the outer surface of the piston 37, whereby the urging force of the spring 39 and the compressed air within the portion 36a of the cylinder 36 becomes greater than the fluid pressure externally of the piston 37 to thereby force the piston 37 to the right (as viewed in Figures 2 and 4). The movement of the piston away from the cylinder wall 36b causes the end wall 43a of the cam slot 43 to slide relative to the cam 53 to thereby force the latch lever 50 upwardly to its raised position (Figure 4) and thereby releases the latch 54 from the upper end of the cocking lever 44 whereupon the hammer spring 47 pivotally swings the cocking lever 44 clock-

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wise (as viewed in Figure 4) to cause the hammer 46 to contact the primer 56. Thus, the primer is detonated to detonate the detonator cord 57 which in turn fires or detonates the primacord 60 for exploding the cast explosive 62.

From the above it will appear that firing means is provided by primacord 60, detonator cord 57, primer 56, hammer 46, spring 47, cocking lever 44, latch lever 50, and spring 52 which detonates charge 62. It will further appear that arming means are provided by piston 37, and the shoulder 66 on rod 40. Of course spring 39 and fluid trapped in the closed portion 36a of cylinder 36 resist movement of the piston 37 when the piston is exposed to an increase in pressure. The spring 39 holds piston 37 and rod 40 in a position to engage cam 53 and maintain the firing mechanism in unarmed position until the device is inserted in a well and subjected to a predetermined well fluid pressure. It will further appear from the above that means for actuating the firing means by releasing the firing means from armed or cocked position to permit it to detonate charge 62 is provided by spring 39 and the pressure trapped in closed portion 36a of cylinder 36 moving rod 40 to a position where inner wall 43a of cam slot 43 engages cam 53 to lift lever 50 to a position where latch 54 on lever 50 releases lever 44 upon a reduction of well fluid pressure on piston 37.

Since the cast explosive is shaped with the acute angle 62a, the explosion occurs in a substantially horizontal plane so that there is no substantial thrust or force longitudinally on the apparatus. The elimination of such longitudinal thrust is important because it prevents the unsettling or release of the packing element 10 of the formation tester A from the wall of the well bore.

The explosion from the charge 62 effects a cleaning off of the mud cake or wall cake which is formed on the interior of the well bore adjacent the well formation F. Since the well fluid in the well bore is at a reduced pressure at the time of the detonation of the explosive charge 62, it is more effective in such cleaning action. Also, because the firing of the explosive charge 62 occurs when the valve of the formation tester A is opened, the mud cake or wall cake is removed for the taking of the sample of fluid and new wall cake does not form until after the fluid sample has been obtained. Therefore, it is believed evident that the mud cake which normally often interferes with the taking of a test sample from a well formation cannot interfere with the taking of the formation test sample when using the apparatus of this invention. It is of course evident that a relatively small volume of the drilling fluid trapped below the packer will be obtained when the formation sample is being taken from the well.

In the usual formation tester, a valve is opened to permit the fluid from the well to enter the drill stem or drill pipe and the valve remains open long enough to obtain the desired sample. Of course, when the valve is first opened, the drilling mud or other fluid in the well below the packer 10 will first enter the drill pipe but the valve of the formation tester is permitted to remain open for a sufficient length of time to allow well fluids from the formation to enter in sufficient quantity that the ratio of the drilling mud which has entered is very small to the total quantity of liquid finally trapped by the formation tester device. In this manner accurate sampling can be carried out.

In Figure 5, a second cleaner device B' is connected to the cleaner device B and is substantially identical in construction so that two formations F and F' can be cleaned of wall cake at the same time. The cylinder 75 which is utilized for connecting together the cleaner units B and B' can be of various lengths so as to vary the distance between the unit B and B' to accommodate use with well formations which are spaced different distances from each other. As will be well understood, the detonator cord or primacord 57 in the cleaner device B can be lengthened to contact detonator cords 60 in both the units B and B'

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so that a single actuator section can fire both units substantially simultaneously. Thus, it would be unnecessary to have an actuator section 24 in the unit B' but instead it would merely include one or more charge sections 25.

Also, although only one charge section 25 is included in the illustration of the invention in the drawings, it will be evident that more than one section 25 could be used if desired.

Although the wall cleaner B of this invention is particularly suitable for use in combination with the formation tester A as described above, it should also be pointed out that the device B can be used effectively as a casing cutter in pulling stuck pipe from a well bore. Other uses of the device B will readily occur to those skilled in the art.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A device for cleaning the wall of a well bore adjacent a well formation to facilitate the obtaining of a test sample from said formation, comprising an annular explosive charge adapted to be exploded in the well bore for blasting off a portion of the wall cake covering the wall of the well formation, means for supporting said charge for detonation in the well bore, firing means for detonating said charge, means for arming said firing means, means for actuating the firing means responsive to reduction of well fluid pressure to a predetermined value for detonating said charge substantially concurrently with the taking of said test sample whereby a portion of the wall cake is removed during the taking of the test sample so that the wall cake does not interfere with the taking of such sample.

2. The structure set forth in claim 1 including means for maintaining the firing means in unarmed position until the cleaning device is subject to a predetermined well fluid pressure.

3. A device for cleaning the wall of a well bore adjacent a well formation to facilitate the obtaining of a test sample from said formation, comprising an annular explosive charge adapted to be exploded in the well bore for blasting off a portion of the wall cake covering the wall of the well formation, means for supporting said charge for detonation in the well bore, firing means for detonating said charge, arming means for arming the firing means upon exposing the arming means to a predetermined increase in fluid pressure by inserting said cleaner device into a well bore, and means for releasing the firing means from armed position to detonate said charge.

4. A device for cleaning the wall of a well bore adjacent a well formation to facilitate the obtaining of a test sample from said formation, comprising an annular explosive charge adapted to be exploded in the well bore for blasting off a portion of the wall cake covering the wall of the well formation, means for supporting said charge for detonation in the well bore, firing means for detonating said charge, arming means for arming the firing means upon exposing the arming means to a predetermined increase in fluid pressure by inserting said cleaner device into a well bore, and means responsive to reduction of well fluid pressure to a predetermined value for releasing the firing means from armed position to detonate said charge.

5. A device for cleaning the wall of a well bore adjacent a well formation to facilitate the obtaining of a test sample from said formation, comprising an annular explosive charge adapted to be exploded in the well bore for blasting off a portion of the wall cake covering the wall of the well formation, means for supporting said charge for detonation in the well bore, firing means for

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detonating said charge, means for maintaining the firing means in unarmed position until the cleaning device is inserted into a well bore, arming means for arming the firing means upon exposing the arming means to a predetermined increase in fluid pressure by inserting said cleaner device into a well bore, and means for releasing the firing means from armed position to detonate said charge.

6. A device for cleaning the wall of a well bore adjacent a well formation to facilitate the obtaining of a test sample from said formation, comprising an annular explosive charge adapted to be exploded in the well bore for blasting off a portion of the wall cake covering the wall of the well formation, means for supporting said charge for detonation in the well bore, firing means for detonating said charge, means for maintaining the firing means in unarmed position until the cleaning device is

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inserted into a well bore, arming means for arming the firing means upon exposing the arming means to a predetermined increase in fluid pressure by inserting said cleaner device into a well bore, and means responsive to a reduction in bore hole pressure fluid to a predetermined value for releasing the firing means from armed position to detonate said charge.

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