

July 10, 1962

F. V. PORTER ET AL

3,043,379

FORMATION SAMPLER

Filed Oct. 1, 1957

3 Sheets-Sheet 1

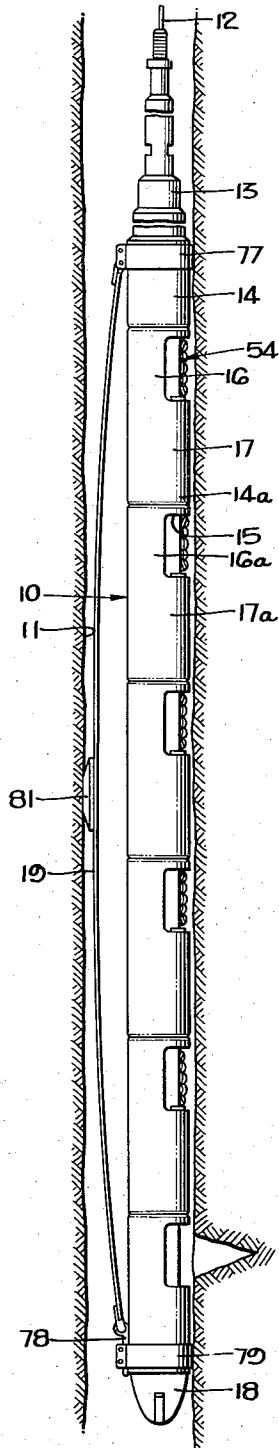


FIG. 1.

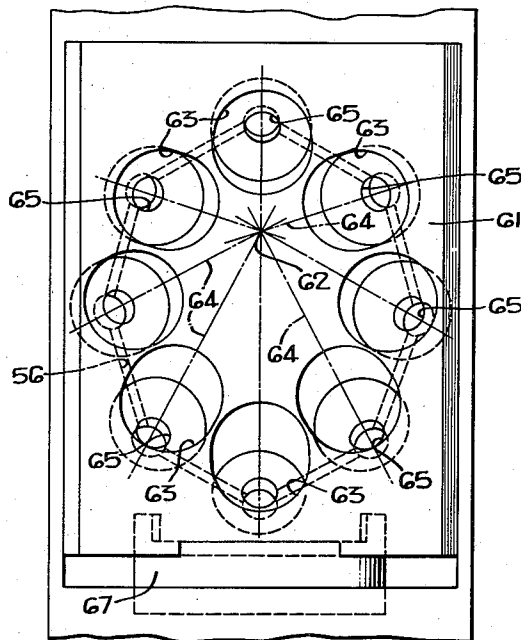


FIG. 5.

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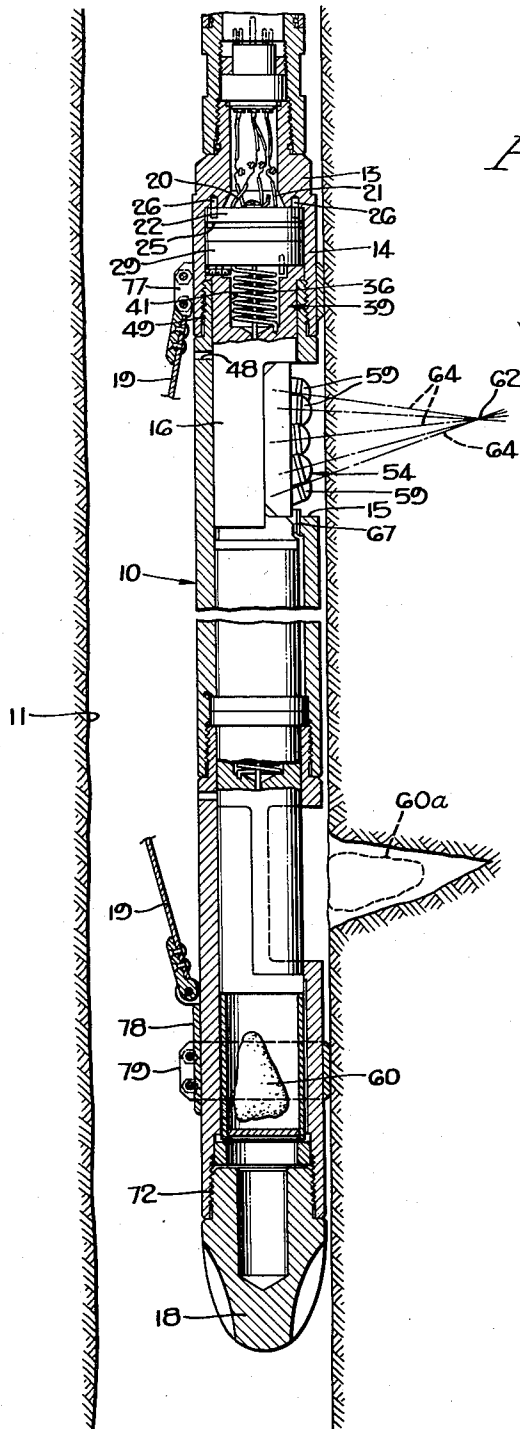
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3 Sheets-Sheet 3

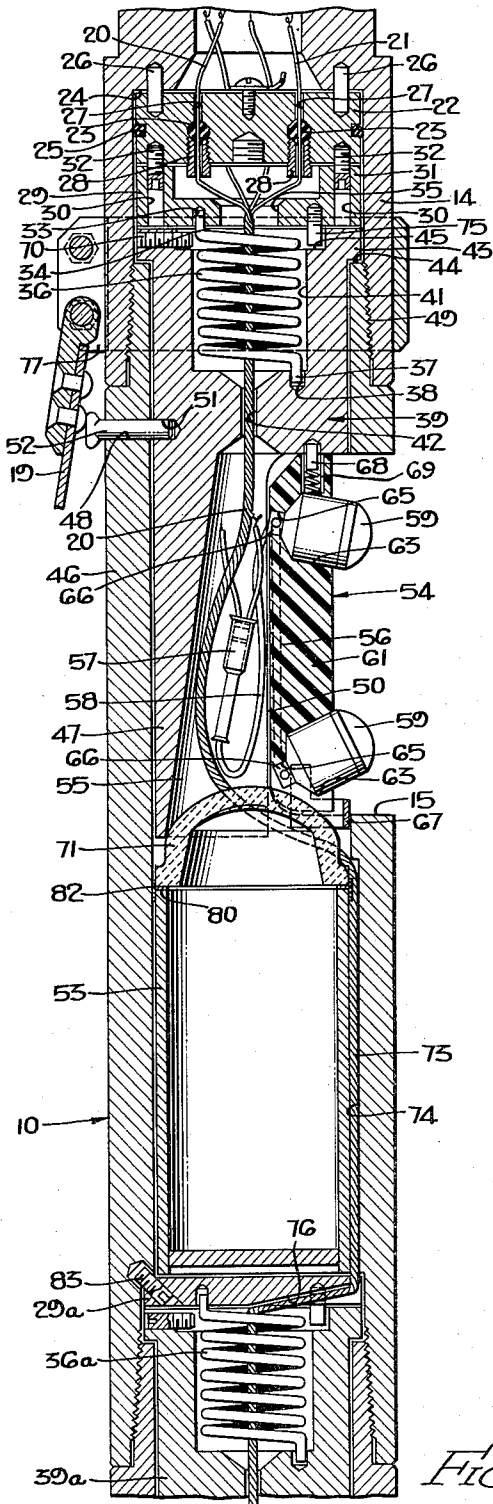


FIG. 3.

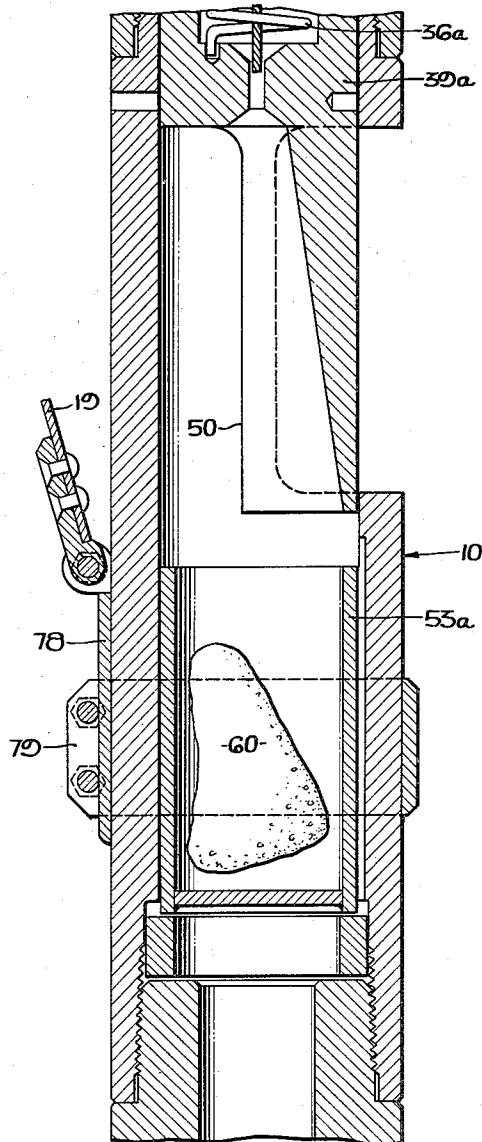


FIG. 4.

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1

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Filed Oct. 1, 1957, Ser. No. 687,430

4 Claims. (Cl. 175—2)

This invention relates to tools for taking samples of the formations penetrated by earth boreholes, and more particularly to improved means of freeing samples from the sidewalls of earth boreholes such as are drilled for producing oil, gas, water and similar fluids and for capturing the freed samples in a receptacle to be retrieved from the borehole.

Sampling of hard sidewall formations in fluid-containing boreholes presents difficult problems. Satisfactory samples free from excessive fracturing, compaction or contamination are needed for analysis and testing to determine the original conditions existing in the formation zone from which the samples were taken. Samples often are required from formation zones at great depth and under extreme fluid pressure and temperature conditions.

In general, an explosively activated earth borehole formation sampling tool is employed. This type of tool includes an elongated gun body adapted to be lowered into such fluid-containing boreholes on a suitable conductor cable. The gun body usually contains a plurality of laterally directed gun bores in each of which is contained a propellant charge and a hollow or tubular shaped cutting projectile adapted to be propelled by the propellant into penetrating impact with adjacent formations to be sampled. The projectiles are each usually held captive to the gun body, both before and after firing, by a flexible wire or cable by means of which the projectile, after firing, can be dislodged from the surrounding formation and retained in attachment to the gun body for subsequent withdrawal from the borehole.

Such sampling tools sometimes fail to satisfactorily penetrate very hard sidewall formations sufficiently to obtain a sample of adequate size for analysis. At other times the sample recovered from the hollow cutting projectile is unduly compacted and does not give an accurate indication of the permeability of the sidewall formation sampled. At still other times the recovered sample is unduly fractured as a result of percussion forces and pressure build-up in the projectile and accurate laboratory analyses cannot be made thereon. In addition, an objectionable amount of contamination of the sample by borehole fluids such as drilling mud sometimes occurs. Also occasionally the projectile becomes stuck in the sidewall formation to the extent that the retrieving cable or wire is broken in attempting to retrieve it.

Accordingly, it is an object of this invention to provide a sidewall formation sampler which is free of all of the hereinbefore described disadvantages and defects.

Another object of this invention is to provide a sidewall formation sampler which is more reliable than prior art samplers in obtaining a satisfactory sample of a very hard sidewall formation at extreme borehole depths and under extreme temperature and fluid pressure conditions.

A further object is to provide a sampler and method which will more often than prior art samplers obtain a sample of very hard sidewall formation in a condition more nearly representative of the original conditions existing in the sampled formation zone in that the retrieved sample is relatively free of compaction, contamination or fracturing.

Briefly stated in general terms, the objects of this invention are attained by sidewall formation sampling apparatus having a hollow body portion carrying a means

2

for freeing a sidewall sample, such as a group of shaped charges arranged so that the gaseous jets from the charges will cut a piece of hard sidewall formation free thereof, and an empty chamber means having a frangible cover which is broken preferably in timed relation with freeing of the sidewall sample so that rushing of borehole fluid into the empty chamber means aids in detaching the sample from the sidewall and capturing it in the chamber means. In a preferred embodiment a closure means such as a door is closed in timed relation with the capture of the sample to enclose the sample in the chamber means in the hollow apparatus body portion and protect it from fluid in the borehole while it is being retrieved for laboratory analysis.

A more detailed description of a preferred embodiment of the invention is given hereinafter with reference to the drawings wherein:

FIG. 1 is an elevational view showing a core collecting tool containing six sampling units disposed in a borehole;

FIG. 2 is a view similar to that of FIG. 1 drawn to a somewhat larger scale and showing upper and lower portions of the tool in longitudinal section;

FIG. 3 is a partial, enlarged longitudinal sectional view showing details of a sampling unit before it has captured a sample;

FIG. 4 is a view similar to that of FIG. 3, showing details of the lower portion of a unit after it has captured a sample; and

FIG. 5 is a partial, enlarged side elevational view showing the orientation of shaped charges employed to free a sidewall sample.

Referring first primarily to the general assembly of the apparatus shown in FIG. 1, 10 is an elongated, generally cylindrical gun body suspended in operating position in a typical earth borehole 11, by a conductor cable 12. The gun body comprises an upper portion 13 which houses an electrically activated switching mechanism (not shown) for electrically firing each individual group of shaped charges in each sampling unit, when more than one sampling unit is incorporated in the same gun body, as herein illustrated; a second portion 14 housing an electric lead wire sealing member and a coil spring for actuating a reinforcing and closure member; a third portion 16 containing a group of shaped charges, supported on a carrier arranged in a laterally outwardly facing position in an opening in the side of the gun body and an explosive-initiating blasting cap therefor; a fourth portion 17 enclosing a sample-collecting cylinder or chamber containing a frangible cap or closure member; a fifth portion 14a containing a spring base member and coil spring similar to the second portion; a sixth portion 16a similar to the third portion; a seventh portion 17a similar to the fourth portion; and so on, depending upon the number of sampling units in the assembly; and finally a bottom end portion 18 consisting of a bull plug. A suitable laterally extending bow spring 19 is attached at its upper end to the upper portion of the gun body 10 and at its lower end to the lower portion of the gun body for urging and positioning the gun body eccentrically with respect to the borehole axis so that the side of the gun body carrying the side openings 15 opposite each sampling unit is held firmly against the side of the borehole.

The cable 12 usually contains one or more insulated electrical conductors (not shown) for electrically interconnecting current supply and control means located outside the top of the borehole with the beforementioned electrically actuated switching mechanism housed within the upper portion 13 of the gun body. The wiring for firing each group of shaped charges, when more than one sampling unit is employed on a gun, such as the six sampling units shown in FIG. 1, includes a number of

3

conductors, one for each group of shaped charges, extending from the switching mechanism to the igniters for each unit. Each of these conductors is electrically connected from the switching mechanism to a lead wire such as shown at 20, 21, etc. (FIG. 3), sealed tight against borehole fluid pressure in a wire sealing member 22, as indicated at 23.

The disc-shaped wire sealing member 22 is mounted transversely in the upper end of the gun body cavity in gun portion 14, and is positioned on an annular seating face formed on an annular shoulder portion 24 of the gun body cavity. It is restrained from turning about the longitudinal axis of the body by pins 26. An O-ring 25 contained in an annular groove in the periphery of the sealing member 22 prevents borehole fluid from entering upper gun body portion 13 which houses the switching mechanism, as described hereinbefore. The lead wires 20, 21, etc., pass through axial channels 27, packing 23 and a threaded packing gland 28, the latter being tightly threaded into sealing member 22, to seal channels 27 against the passage of borehole fluid upwardly into the switching mechanism.

A spring base 29 which is also disc-shaped is contained in housing 14 under the wire sealing member 22. The spring base 29 is provided with an outer, upwardly-extending annular flange 31 containing holes 30 positioned to align with tapped holes in the lower marginal portion of the sealing member 22. Setscrews 32 are threaded through the aligned holes 30 in the spring base and into the lower portion of the sealing member to restrain the former from rotation relative to the latter. A passage 35 for lead wires 20, 21, etc., is cut through the center of spring base 29. An off-center socket 33 also is provided in the lower side of the spring base in an appropriate location to receive the upper end 34 of a closure-actuating coil spring 36. The lower end 37 of the spring 36 is similarly positioned in a socket 38 formed in a closure member 39 more fully described hereafter.

The closure member 39 is provided with a cylindrical cavity 41 bored axially into the top of the pad to receive the beforementioned spring 36. A hole 42 is bored centrally through the bottom of the cavity 41 for passage therethrough of the wires 20, 21, etc. The upper end of the closure member 39 is provided with a radially-extending, annular flange 43 which forms an external, downwardly-facing annular shoulder. This shoulder bears on the upper end surface 44 of a gun body section 46 as the closure member 39 is rotated under the power of spring 36, as hereinafter described. An annular shoulder 45 is cut along the upper edge of cavity 41. A setscrew 70 is threaded through the wall of closure member 39 to protrude inwardly thereof just above the shoulder 45. Another setscrew 75 is positioned diametrically opposite setscrew 70 and is threaded into the bottom of spring base 29 to protrude downwardly to the shoulder 45.

The lower portion 47 of the closure member 39 is cylindrical in shape on the outside and is provided with a cavity 55 on the inside having a downwardly diverging, frusto-conical shape. About half of the wall of this portion of the closure member is cut away on a vertical plane as shown at 50 to form a side opening thereinto. A passage 48 is drilled radially through the wall of gun body section 46 which is screwed into body portion 14 as shown at 49. A radial hole 51 is drilled into the side of the closure member 39 to align with the passage 48 so that a safety locking pin 52 can be placed temporarily into the aligned holes. Pin 52 will safely maintain the spring 36 and closure member 39 in an initially loaded condition with the side opening in the cavity 55 aligned with side opening 15 in the gun body section 49, while the gun is provided with a sample-collecting cylinder 53 and a shaped charge assembly 54.

When the spring 36 is loaded by turning the closure member 39 around its longitudinal axis through an angle of about 180°, the opening 15 is thereby placed in

4

registry with the cut-away region of the closure member as shown in FIGURE 3. The loading and orientation of the closure member is governed by the stop-action of setscrew 75 on setscrew 70. The wire 20 is connected to a blasting cap 57 which in turn is connected to an explosive cord or detonating fuse 58. The explosive cord 58 is in turn connected to each of the shaped charge units 59 in the assembly 54. The shaped charge units 59 are supported in a carrier 61 and arranged so that, when fired, the gaseous jets issuing therefrom converge upon a point 62 external of the opening 15 and of the gun body (FIGS. 2 and 5) in the adjacent sidewall formation, and cut free a sidewall formation sample 60 having a form approximating that shown in dotted lines 60a in FIGURE 2.

The shaped charge carrier 61 is made of a frangible material such as Bakelite or similar plastics, ceramics, non-metallic or metallic materials capable of being disintegrated by the explosive forces of the shaped charges 59. A series of cupped depressions 63 is formed in the carrier of appropriate shape to hold the shaped charges 59. The cupped depressions are arranged in a generally round, preferably elliptical, pattern, as shown in FIG. 5. The axes 64 of the cupped depressions 63 preferably are inclined and directed so that they meet in a point 62, as hereinbefore mentioned. Point 62 is positioned somewhat above the central, laterally extending axis of the carrier, as shown in FIGURES 2 and 5 to facilitate downward and inward movement of a separated sidewall sample body from the sidewall into the sample collecting portion of the tool. This arrangement has been found to result in recovery of relatively large samples in good condition.

Each of the cupped depressions 63 is provided with a rearward aperture 65 passing through the carrier 61 at the bottom of each cupped depression. It is dimensioned to receive the rear booster containing portion 66 of the housing of a shaped charge adapted for detonating the shaped charge by means of the explosive cord 58. A channel 56 is cut into the rear surface of the carrier 61 to interconnect apertures 65 and receive the explosive cord 58 connecting the booster portions 66 of the several shaped charges. Each of the shaped charges is constructed, in general as illustrated in copending application of Forrest V. Porter Serial No. 322,963, filed Nov. 28, 1952, now abandoned. The carrier 61 can be mounted in the opening 15 in any convenient manner, such as by the use of an arcuate bottom support member 67 and spring-urged pins 68. Holes 69 also are provided in the carrier to receive fasteners for attaching the assembly 54 to the gun body section 46.

A sample collecting chamber or cylinder 53 having a cylindrical sidewall permanently closed at the bottom is open at the top. The top of the cylinder 53 is covered by a frangible lid or dome 71, composed of a ceramic material, for example, and the covered cylinder is placed inside gun body section 46. Instead of being made of ceramic materials, the cover 71 can be made of other suitable frangible materials such as plastics, non-metallic or metallic materials that will be shattered or substantially disintegrated by the explosive forces of the shaped charges 59. The cover 71 is tightly fitted over cylinder 53 with the aid of adhesive and adhesive tape as indicated at 80 and 82, respectively.

A second unit substantially duplicating the first and consisting of a spring base 29a, coil spring 36a, closure member 39a, cylinder or chamber 53a and cover (not shown) is mounted in the gun body 10 below the first unit just as described above in connection with the description of the first unit. Spring base 29a is removably fastened transversely in the gun body by setscrews 83 as shown. Similar, successive third, fourth and fifth units also are included, as shown. More or less than six units can be included, as desired.

The bull plug 18 is threaded at 72 into the lower end

5

of the gun body 10 and retains the lowermost sample-collecting cylinder and cover in position below the adjacent shaped charge assembly. Bull plug 18 is made to have a heavy-walled construction and is provided with a pointed lower end as shown to facilitate and speed lowering of the apparatus in a borehole containing a dense fluid under extremely high pressure.

The second lower shaped charge assembly is connected to lead wire 21 of the group of lead wires, 20, 21, etc. The group of remaining lead wires 73 is threaded through vertical groove 74 cut into the wall of gun body section 46 and a passage 76 cut through spring base 29a, as shown. The successive third, fourth and fifth lower shaped charge assemblies are each similarly connected to one of the group of lead wires 20, 21, etc.

The bow spring 19 is pivotally fastened at its upper end to a bracket 77 clamped around gun body portion 14 and at its lower end to a lug 78 connected to a bracket 79 clamped around gun body 10. The lug 78 is positioned in bracket 79 and clamped therein so that the bow spring 19 is bowed the desired degree. A shoe 81 is attached to the outer side of the middle of the bow spring 19 to protect it from wear which would otherwise occur at the point of sliding contact against the sidewall of the borehole 11. The pressure exerted by spring 19 and its characteristics are made such that it will hold the side of the gun from which the shaped charges 59 are fired, firmly against the adjacent sidewall formation so that the desired sidewall sample will be properly freed from the sidewall and will be captured in the collecting cylinder 53.

To operate the sampling apparatus the safety locking pin 52 is withdrawn from the aligned holes 48, 51 for each of the several closure members 39 in the assembled gun. The carrier 54 in each sampling unit retains the closure member 39 in position against the loaded coil spring 36. The properly prepared gun body 10 is lowered into a borehole 11 to the depth at which it is desired to obtain a representative sample of the sidewall formation. From the top of the borehole 11 the desired shaped charge unit 59 is fired electrically through the cable 12 and as determined by the switching mechanism in gun portion 13. In the drawings the bottom shaped charge unit is shown to have been fired first. It will be seen that in this manner several sampling units, each containing a separate group of shaped charges, can be incorporated in the same gun body and each unit can be separately fired at will to obtain several samples from several widely separated locations without withdrawing the gun body from the borehole after each firing operation. In such operation the electric current passes into the desired wire, such as wire 20, for example, as determined by the switching mechanism and ignites blasting cap 57. The resulting detonation is transferred through explosive cord 58 to the shaped charge unit 59, detonating it almost instantaneously.

The gaseous jets from the detonated shaped charges 59 penetrate the sidewall formation opposite the opening 15 in the gun body and a sample 60 of the sidewall formation is thereby freed. At about the same time the forces produced by the discharge of the blasting cap 57, the explosive cord 58 and the shaped charges 59, destroy the carrier 54 and the collecting cylinder cover 71 by fracturing and reducing them to small pieces. Upon such disintegration of the cover 71, the fluid pressure in the borehole causes the borehole fluid to rush rapidly into the collecting cylinder 53 to fill the space therein previously occupied by air at substantially atmospheric pressure. This rushing movement of the borehole fluid applies suction to the freed sidewall sample 60 and draws it into the collecting cylinder 53 through the gun body opening 15.

Disintegration of the carrier 54 and cover 71 also releases the closure member 39 which was prevented from rotating by carrier 54. Loaded coil spring 36 rotates

6

closure member 39 about its longitudinal axis through an angle of about 180°, as determined by the stop action of setscrew 75 on setscrew 70, to the closed position, as shown in the lower unit in FIGS. 1, 2, and 4, to close gun body opening 15. Closure member 39 thus securely traps the collected sidewall sample in collecting cylinder 53 and excludes additional borehole fluid from contact with and washing of the captured sample. The appearance of the thus completed sampling operation is shown by the appearance of the bottom unit in the drawings. The weight and consequent rotational inertia of the closure member 39 somewhat delays its rotational closing action. This insures a completion of the jet action freeing of the sidewall sample and capture of the resultant sample inside the collecting cylinder 53 inside of the gun body before the gun opening 15 is closed by rotation of closure member 39. The closure member 39 is made heavy in construction with a tapered lower door portion 47 to protect and reinforce the gun body against deformation damage caused by the discharge of the shaped charges 59.

Instead of using individual shaped charges 59, as illustrated herein, a single continuous shaped charge having an elliptical or circular contour, for example, as disclosed in the copending application of Forrest V. Porter, to which reference was made above, can be used to cut the sidewall formation sample from the sidewall. The cutting sheet of gases produced in such latter case is directed toward a point 62 to cut free a sidewall sample in a manner similar to that described hereinbefore using a series of separate jet streams.

While the invention has been herein illustrated and described in what is now considered to be a preferred embodiment, it is to be understood that the invention is not limited to the specific details thereof, but covers all changes, modifications and adaptations within the scope of the appended claims.

What is claimed is:

1. A formation sampler comprising: a body member having a cavity therein and an opening establishing communication between the cavity and the medium outside the body member; shaped charge means disposed in the body member and arranged in the form of a closed pattern for freeing a sample of formation material from the wall of a borehole upon explosion thereof; chamber means disposed in the cavity of the body member below the opening; frangible cover means capable of excluding borehole fluid from the chamber means positioned adjacent the body member opening and the shaped charge means and adapted for disintegration by explosion of the shaped charge means; a frangible carrier for said shaped charge means and adapted for disintegration by the explosion thereof; and spring-loaded closure means on said body positioned against said carrier and held open thereby, said closure means adapted for closing the opening upon release by disintegration of said carrier after the freed sample has had sufficient time to pass through the opening and into the cavity.

2. A formation sampler comprising: a body member having a cavity therein and an opening establishing communication between the cavity and the medium outside the body member; a plurality of shaped charge means disposed in the body member inside the opening and arranged in the form of a closed pattern for freeing a sample of formation material from the wall of a borehole; chamber means disposed in the cavity of the body member below the opening and the shaped charge means; frangible cover means capable of excluding borehole fluid from the chamber means positioned below the body member opening and the shaped charge means and adapted for disintegration by explosion of the shaped charge means; movably mounted closure means disposed adjacent the opening in the cavity of the body member loading means for urging said closure means to a closed position; frangible stop means positioned in the opening for holding the closure means against such closing of the opening; and

7

means for detonating the shaped charge means, the explosion of said shaped charge means being effective to disintegrate said stop means and thereby release the closure means for enclosing the chamber means and sample inside the body member.

3. A formation sampler comprising: a generally cylindrical body member having a cavity formed therein and an opening establishing communication between the cavity and the medium outside the body; a frangible carrier covering the opening; shaped charge means mounted on said frangible carrier and adapted to disintegrate the same upon explosion; a closure member positioned within said body including an annular portion and a depending door portion; a loading spring connected to said closure member and adapted to rotate the same to a position aligning said door portion with the opening thereby to close said opening, said annular portion being initially held in a predetermined angular position by an edge of said frangible carrier bearing against it with said door portion being angularly spaced from the opening; and means for detonating said shaped charge means, the detonation of said shaped charge means being effective to dislodge said well sample, disintegrate said frangible carrier and release said closure member for rotation of the door portion into a position closing the opening.

4. A formation sampler comprising: an elongated, generally cylindrical hollow body; means forming an opening in the exterior of said body; a frangible stop member

8

closing said opening; explosive means carried on said stop member for freeing a sample of formation material from a borehole wall, said explosive means adapted to disintegrate said stop means upon explosion of said explosive means; chamber means, having a top end portion, positioned within said body below said explosive means; frangible means, in close proximity to said explosive means and adapted to be disintegrated by explosion of said explosive means, closing said top end portion of said chamber means; moveable closure means bearing against said stop member; and spring means urging said closure means against said stop and effective to move said stop member to a position closing the chamber means and sample captured therein with respect to material exterior of said sampler after disintegration of said frangible stop member and said frangible means by explosion of said explosive means.

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