

Feb. 13, 1951

D. M. SMITH
CORING DEVICE

2,541,785

Filed Aug. 22, 1946

3 Sheets-Sheet 1

FIG. 1

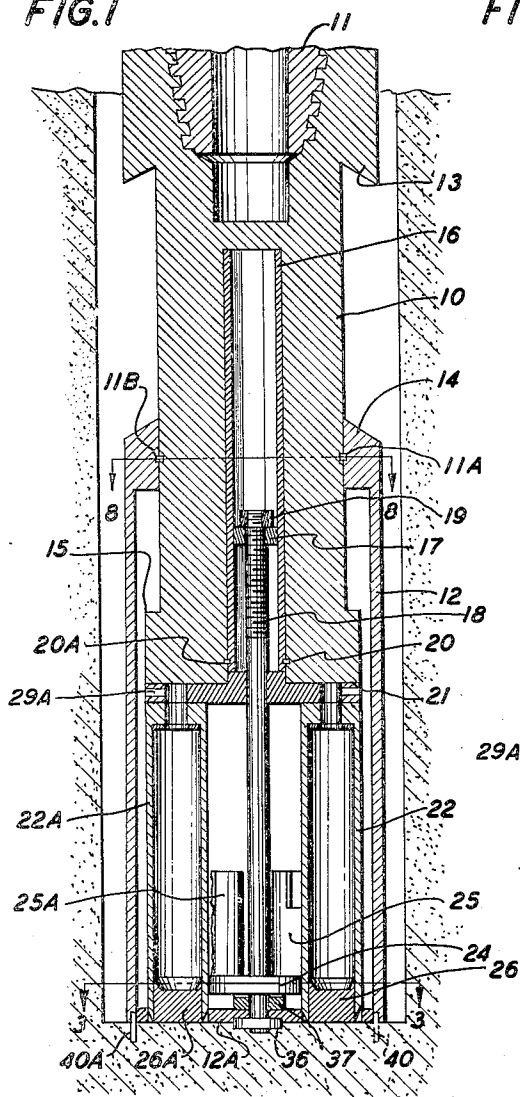


FIG. 2

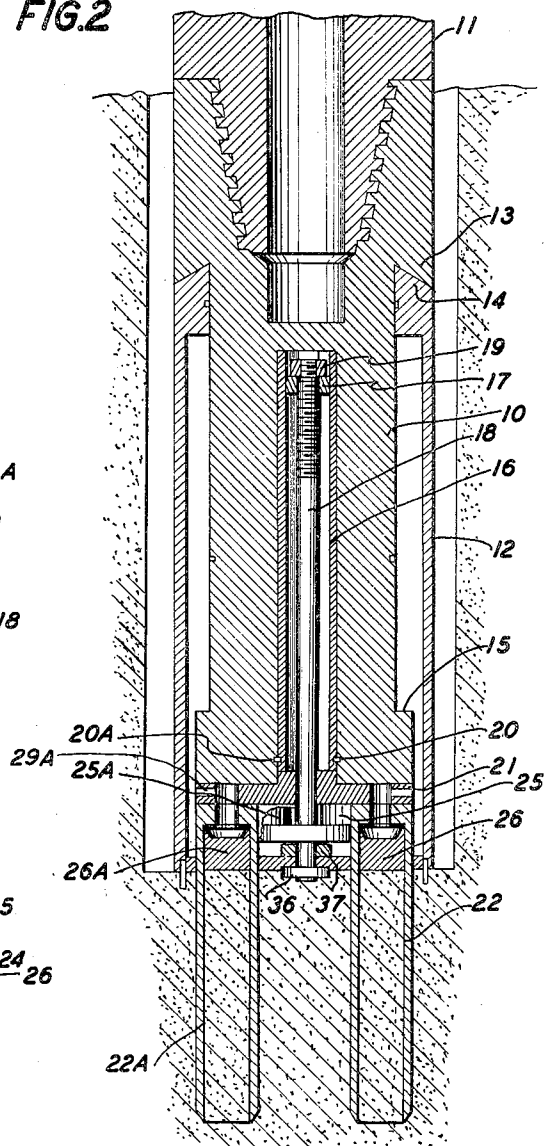
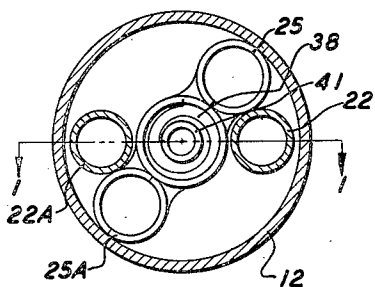


FIG. 3



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FIG. 4

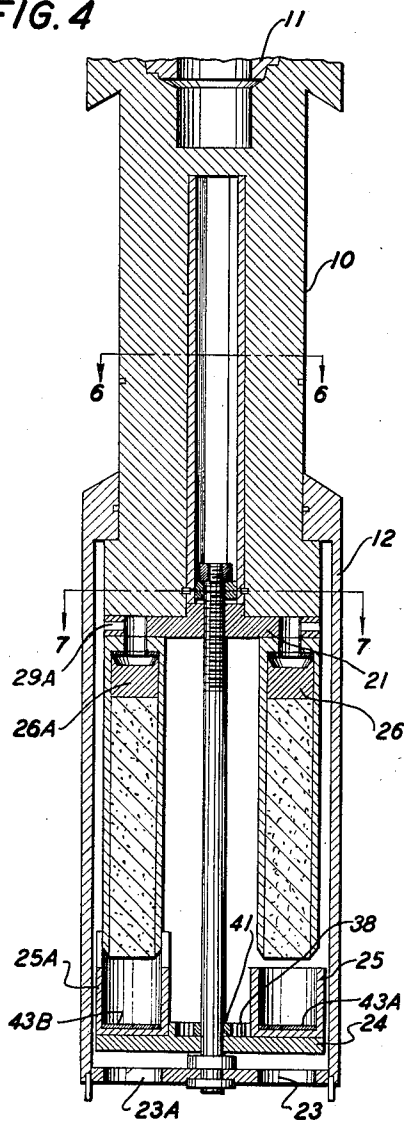
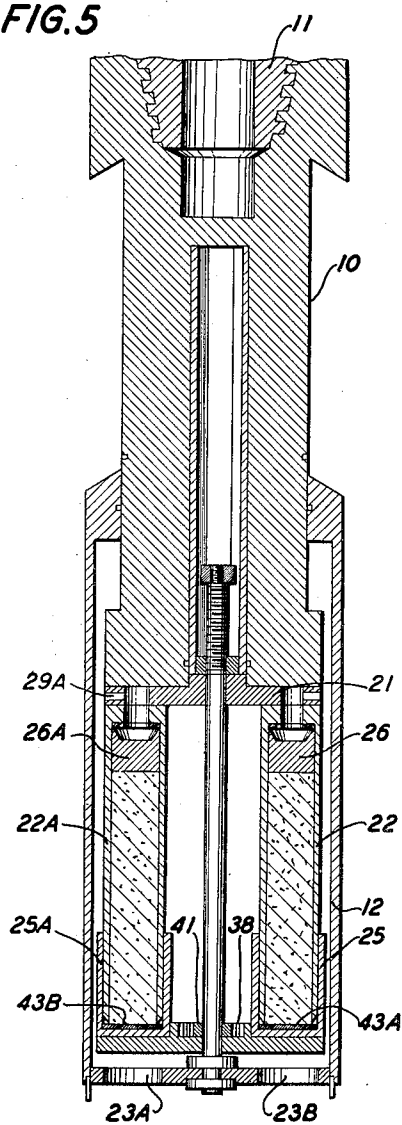


FIG. 5



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FIG. 6

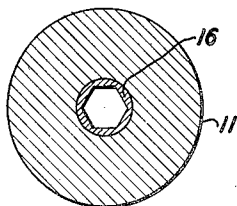


FIG. 7

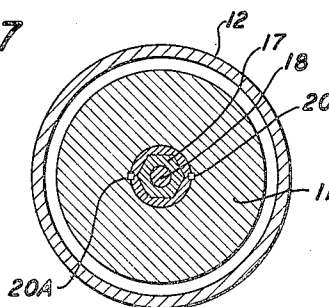


FIG. 8

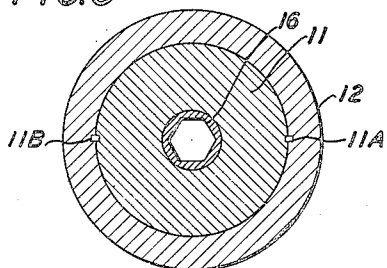


FIG. 9

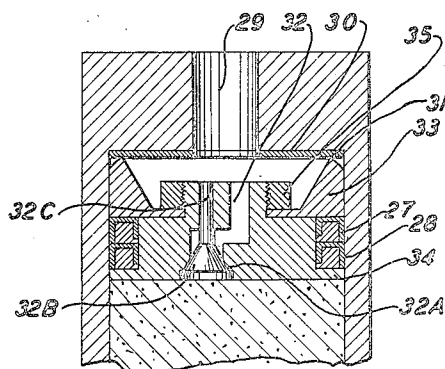


FIG. 10

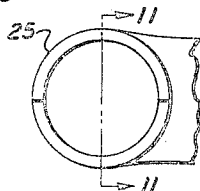
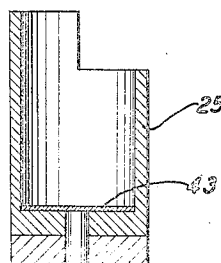


FIG. 11



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2,541,785

CORING DEVICE

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Application August 22, 1946, Serial No. 692,165

9 Claims. (Cl. 255—1.4)

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This invention is concerned with coring in bore holes and provides novel apparatus to the end that cores may be taken in rotary drilling operations and the like without contamination of the core and without loss of fluid therefrom.

In recent years, increasing attention has been paid to core analysis in oil well drilling and the like. Data obtained from cores taken in such drilling are used in evaluation of oil reserves, in estimating the productivity and ultimate production of oil sands, in planning oil field development programs and for several other purposes. Heretofore, the data obtained in many coring operations has been misleading due to erratic contamination of the cores by drilling fluids and to loss, prior to analysis, of fluids originally contained in the cores.

There is a distinct need for a coring device which will permit the taking of a core on the bottom of a hole without contamination of the core (either in the coring operation per se or in bringing the core to the surface and thence to the laboratory) and without the loss of formation pressure with consequent expulsion of the major portion of liquid and gas from the core.

As a result of my investigations, I have developed a core barrel apparatus of the pressure type (i. e. one in which the coring tube or barrel is pressed downwardly into the formation to be sampled) so constructed that contamination of the sample during the coring operation is prevented in large measure, the sample being sealed immediately after it is taken from the bottom of the hole, so that any fluid in the core may be brought to the surface within the barrel at formation pressure and thus retained.

The apparatus of my invention results in more accurate core information, with the result that interpretation of the data taken from the cores is likewise more accurate and permits more nearly correct evaluation of oil field properties, better estimates of reserves and more accurate location of oil-water interfaces within an oil producing formation to the end that there may be improved recovery therefrom by gas or water injection. To be more specific, the pressure core barrel of my invention gives superior results in the determination of reservoir content, in the location of gas caps and oil producing formations, and in the determination of the content of the gas cap.

With pressure-type core barrels heretofore available, the cores have been taken while surrounded by drilling fluid. When these cores are removed from the hole, the volume of the cores represents in many cases only 25% of the volume under pres-

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sure within the core barrel, the remaining 75% being drilling fluid. As a result, the measurement of oil contained in the core is reasonably accurate, but the amount of water is distorted due to the invasion of drilling fluid. This problem is solved by the instant invention.

To summarize, the pressure core barrel of my invention has the following advantages:

a. Simplicity and inherent ruggedness of construction, with few moving parts and simple operation;

b. Ability to extract duplicate cores, thus providing check samples;

c. The prevention of most of the contamination of and loss from cores which has heretofore occurred, since nearly all of the volume within the sealed core barrel is occupied by the sample itself; the drilling fluid is excluded from the coring zone during the coring operation; and the sample is sealed at formation pressure in the bottom of the hole.

In essence, my invention contemplates the combination in apparatus for taking a core from the bottom of a drill hole, which comprises a core barrel fastened to the bottom of a drill stem in alignment therewith and open at the lower end with a cutting edge that is driven into the formation by the weight of the stem, together with means for closing the bottom or cutting end of the barrel while it contains the core and is in the bottom of the hole, so that a sample may be sealed in the barrel at the formation pressure and withdrawn in its original condition.

In its preferred form, the apparatus comprises a mandrel mountable on the bottom of the drill stem in alignment therewith, a shell or sleeve slidably mounted upon the mandrel, a core barrel mounted on the bottom of the mandrel, with an open lower cutting end, and a closure member adapted to close the lower end of the core barrel when the mandrel is slid upward with respect to the sleeve.

If desired, the mandrel and sleeve may be held in fixed position initially by a shear pin or other rupturable means which permits disengagement of mandrel and sleeve when weight of the drill stem is rested on the mandrel in the bottom of the well.

It is preferable to provide at least two core barrels with equivalent closure means so that duplicate samples may be taken from the formation being tested.

In the preferred form of the apparatus, the top of the core barrel is open, and a sealing plug is provided within the barrel which is slidable up-

ward therein under the force of the sample being cut. For example, the plug may slide upward to an apertured seat so as to drive drilling fluid or the like upwardly out of the core barrel and keep it out of contact with the sample.

The apparatus should be provided with means, preferably actuated through the rotation of the mandrel, for compressing the closure means against the bottom of the core barrel after the sample is taken, thus assuring a tight seal. One preferred form of clamping means comprises a sealing nut of non-circular section mounted in a corresponding longitudinal bore in the mandrel. The sealing nut is threaded on a bolt which bears against the closure means. By rotating the mandrel, the sealing nut draws the bolt upward with respect to the core barrel and presses the closure means (say a cap) tight against the bottom. If desired, the sealing nut may be mounted within a wrench sleeve which is of circular outside cross section, this sleeve in turn being mounted in a circular bore in the mandrel and held in position by a shear pin or the like. When adequate clamping pressure has been exerted by the bolt, the shear pin ruptures and prevents damage to the core barrel and the rest of the assembly.

It is desirable to provide shoulders on the mandrel and also on the sleeve to limit the relative longitudinal sliding movement of these two members and to prevent the sleeve from sliding off the bottom of the mandrel.

The closure means for sealing the bottom of the core barrel preferably is a cap or cup mounted on the sleeve and rotatable on an axis parallel (and preferably coaxial) to that of sleeve and mandrel. Preferably the cap or cup is mounted on a yoke which is spring actuated. In the initial position assumed by the apparatus in the hole, the closure means is prevented from swinging over the end of the core barrel by the core barrel itself. When the core barrel and mandrel are pulled upward with respect to the sleeve after the sample is taken, the spring forces the cup to swing underneath the core barrel, after which rotation of the drill stem, with consequent rotation of the mandrel, causes the sealing nut to turn on the center bolt and pull the cup tight against the bottom of the core barrel. At the same time, the sealing plug is pushed upwardly in the core barrel tight against its seat. This preserves formation pressure in the core barrel.

Preferably the bolt works through an upper yoke attached to the core barrel and a lower yoke attached to the sealing cup. As the nut is tightened on the bolt, the yokes are forced toward each other, squeezing the ends of the barrel between them and sealing both ends; the upper end by pushing core and plug against its seat, the lower end with the cup. This assembly is detachable from the apparatus and may be removed in toto for transport to the laboratory, thus assuring that the core is delivered for analysis at formation pressure.

The invention will be understood more thoroughly in the light of the following detailed description of a presently preferred form of the apparatus, taken in conjunction with the accompanying drawings in which

Fig. 1 is a sectional elevation of the coring device in position in the bottom of a bore hole just before the core cutting operation;

Fig. 2 is a sectional elevation of the apparatus of Fig. 1 just after the cores have been cut;

Fig. 3 is a cross-sectional plan through the

lower portion of the apparatus of Fig. 1, taken along the line 3—3 and showing the sealing cups held to the sides of the coring tubes by the latter themselves;

Fig. 4 is a sectional elevation showing the apparatus with the cores extracted from the formation and prior to sealing;

Fig. 5 is a longitudinal section of the coring device in sealed condition ready to come out of the bore hole;

Fig. 6 is a cross section taken along the line 6—6 of Fig. 4 showing the wrench sleeve within the mandrel;

Fig. 7 is a cross section taken along the line 7—7 of Fig. 4 showing the shear pins attaching mandrel to wrench sleeve;

Fig. 8 is a cross section taken along the line 8—8 of Fig. 1 showing the shear pins which initially hold the mandrel in fixed relation to the sleeve;

Fig. 9 is an enlarged fragmentary cross-sectional elevation of the top of one of the coring tubes or barrels showing the manner in which it is sealed;

Fig. 10 is an enlarged plan view of one of the sealing cups of the device of the foregoing figures; and

Fig. 11 is a cross-sectional elevation of the sealing cup of Fig. 10 taken along the line 11—11 of this figure.

In essence, the apparatus illustrated by the figures comprises a mandrel 10 adapted to be fastened by a conventional tool joint on the bottom of a rotary drill stem 11. The mandrel slides in an outer sleeve 12, after a first set of shear pins 11A, 11B have ruptured (see Fig. 1). The outer sleeve or shell has a removable bottom disc threaded or otherwise fastened therein.

The mandrel is cylindrical in cross section and carries an upper beveled shoulder 13, which slides down to mate with a lower shoulder 14 on the sleeve. The mandrel has an inner shoulder 15 which prevents the outer sleeve from sliding off the lower end of the mandrel.

Within the mandrel is a concentric inner cylindrical bore in which a wrench sleeve 16 is slidably disposed. This wrench sleeve is of outside cylindrical cross section but has an inside tube of hexagonal cross section within which slides a right hand sealing nut 17 that is threaded on a center bolt 18. The sealing nut is prevented from coming off the upper end of the center bolt by means of a left hand lock nut 19.

Until the final sealing operation, the wrench sleeve is rigidly fastened inside the mandrel by a pair of shear pins 20, 20A (see Fig. 1 and Fig. 7).

An upper yoke 21 is mounted rigidly on the bottom of the mandrel and carries a pair of core tubes or barrels 22, 22A. The function of the upper yoke, which connects the upper parts of the coring assembly, is to transmit the sealing pressure from the sealing nut to the core tubes. It is rigidly but detachably mounted on the mandrel.

The core barrels are disposed opposite each other with their axes parallel to that of the center bolt. The bottom edges of the two barrels are beveled to a sharp edge to permit penetration of the formation to be sampled, and the bore of each barrel is somewhat larger in its upper section so that it tends to retain and extract the core from the formation. The coring tubes are attached rigidly to the drill stem through the upper yoke and the mandrel so that

the entire weight of drill collars and pipes may be put on the coring tubes to push them into the formation to be sampled, as shown in Fig. 2.

The bottom of the sleeve is provided with a pair of cylindrical holes 23, 23A to permit the passage of the coring tubes to the bottom of the shell into the formation. (See Fig. 4.)

The apparatus is provided with a lower yoke 24 effectively mounted on the axis of the sleeve and rotatable around the lower portion of the center bolt. The lower yoke carries a pair of sealing cups 25, 25A which are rotated to seal the bottom of the coring tubes as described hereinafter. The center bolt passes through both yokes.

The respective coring tubes are provided with sealing plugs 26, 26A. At the beginning of the coring operation, as shown in Fig. 1, these plugs are located in the bottoms of the tubes. As the cores are cut, the plugs are pushed to the top of their coring tubes by the cores.

Referring to Fig. 9, the plugs are equipped with packing rings 27, 28 which bear against the inside of the coring tubes and provide a lateral seal. The top end of each coring tube has an open bore 29 connecting with side outlets 29A in the upper yoke 21 through which mud or other material may be expelled. Each coring tube is provided with an annular soft metal seal 30 just below the outlet bore, and the sealing plug is provided with an annular knife edge 31 which bears against the soft seat and seals the top of the coring tube in one of the later phases of the operation as described hereinafter. Each sealing plug is provided with a valve 32 which is closed by the core itself when it pushes the sealing plug to the top of the coring tube. This valve permits accidentally entrapped fluid to be ejected.

The valves in the sealing plugs are simple affairs comprising a seat 32A and a frusto-conical closure member 32B, which is mounted on the lower end of a stem 32C that slides in a vertical bore in the top of the plug.

The sealing plug is in two parts, an upper portion 33 and a lower portion 34. The lower portion may be tightened against the upper portion by means of a nut 35 in order to squeeze the packing rings outwardly.

A retaining nut 36 is screwed on the bottom of the center bolt which passes through a rotation bearing 37 mounted concentrically on the bottom of the sleeve.

As shown particularly in Figs. 3 and 4, the lower yoke tends to be rotated by means of a spiral spring 38 placed around the collar 41 in a recess in the lower yoke. The spring, however, cannot move the sealing cups into the sealing position until the coring tubes have been withdrawn upwardly, as shown in Fig. 4.

The sleeve or shell serves four functions. It prevents the clogging of the coring assembly. Its shoulders prevent vertical motion when the end of desired movement is reached. After the core has been cut and the drill string is lifted, the weight of the sleeve causes the lower part of the coring assembly to remain stationary until the sealing cups have slipped into position under the coring tube, as shown in Fig. 4. When the drill string is rotated to tighten the sealing nut on the upper yoke, the outer shell prevents rotation of the center bolt, being assisted in this action by two short fish tail blades 40, 40A on its bottom.

It may be noted that the center bolt is free to slide relative to the upper coring assembly, but is rigidly connected to the outer shell 12. Its func-

tion is to force the coring tubes into the sealing cups and hold the assembly under pressure when it is brought out of the hole.

As already indicated, the sealing cups are actuated by the spiral spring located in a recess in the lower yoke. The spring is fastened to a collar 41 on the center bolt, which in turn is attached to the bolt by a shear pin (not shown). The spring reacts against the lower yoke and aligns the sealing cups with the coring tubes after the samples have been cut.

The sealing cups have extended lips on one side of their upper edge in order to hold the cups in alignment with the coring tubes against the tension of the spiral spring. Soft metal discs 43A, 43B in the bottom of the cups bear against the cutting edge of the coring tubes when the assembly is sealed. (See Figs. 4, 5 and 11.)

The operation of the apparatus is as follows:

The initial position of the apparatus just before the cores are cut is shown in Fig. 1. As shown in this figure, the center bolt has been rotated counterclockwise until the sealing nut has impinged against the lock nut at the top of the bolt. This prevents further rotation of the center bolt and provides the spiral spring with a stop against which to work in moving the sealing cups at a later stage in the operation. The spring is attached to the center bolt by the collar and shear pins, as described hereinbefore.

In assembling the apparatus for use, the sealing cups are rotated against the spring force until they are clear of the coring tubes, and the center bolt is pushed up in the wrench sleeve until its lower end is flush with the lower end of the outer shell or sleeve, which in turn is flush with the lower end of the coring tubes. The relative positions of the coring tubes and the sealing cups are shown in Figs. 1 and 3. The center bolt is fastened to the shell with the retaining nut at the bottom, and the shell is held in position by the shear pins running through its upper portion to the mandrel.

At the beginning of the coring operation as shown in Fig. 1, the sealing plugs are flush with the bottom of the coring tubes. The sealing plugs are held in place by friction against the inside walls of the tubes.

When the coring device has been assembled as described, it is threaded on the bottom of the drill string and lowered in the bore until it rests on the bottom of the hole. When the bottom of the shell encounters the hole bottom, the weight of the drill pipe is transferred to the shear pins 11A and 11B which lock the mandrel to the shell. These pins shear, and the weight of the drill string drives the coring tubes into the bottom of the formation.

During the core-taking operation, the sealing plugs keep mud and mud cake out of the lower parts of the coring tubes. As the coring tubes move downward, the shell is pushed up relative to the mandrel, and at the same time the cores move the sealing plugs upward in the coring tubes and force the mud above them out of the tubes through the bores 29 and outlets 29A.

In the next operation, the drill string is lifted so that the coring tubes are brought up in the shell, as shown in Fig. 4. The weight of the shell itself causes it to remain on the bottom of the hole until the inner shoulder 15 of the mandrel catches against the top of the shell. Before this point has been reached, the coring tubes have slipped up past the sealing cups sufficiently far to permit the spiral spring to rotate the lower

yoke so that the cups are swung under the coring tubes. In other words, the sealing cups snap into position underneath the coring tubes and are held in that position by spring tension.

In the next stage of the operation, the drill pipe is lowered until it is certain that the tool is again on the bottom of the hole. This lowering operation anchors the shell against the bottom and moves the tubes down into the cups so that they seat therein (see Fig. 5). Next, the drill pipe is rotated. The shell and center bolt are held stationary by contact with the bottom, so that the rotation of the drill pipe imparted to the sealing nut through the wrench sleeve causes the sealing nut to thread downwardly on the center bolt and bear against the upper yoke. This forces the lower edges of the coring tubes into the soft metal gaskets in the bottom of the sealing cups as the upper and lower yokes are brought closer together. At the same time the plugs in the top of the tubes are squeezed into their seats and seal the tops of the tubes.

At a predetermined wrench force on the sealing nut, the pins 20 and 20A between the wrench sleeve and the mandrel are sheared, so that no further tightening action is permitted. This set of shear pins thus prevents excessive pressure from being exerted upon the sample tubes and the rest of the assembly.

When the drill pipe is rotated, the coring assembly rotates against the tension of the spiral spring, and as this rotation continues, the spring shears the collar away from the center bolt, this operation taking place after the coring tubes have entered the cups. It will be noted that the lower yoke is set on a bearing and is free to rotate about the center bolt after the spring is released.

As soon as the shear pins which connect the wrench sleeve to the mandrel have been released, the coring assembly assumes the position shown in Fig. 5 and is ready to come out of the hole.

After the coring device has been withdrawn to the surface, it is detached from the drill string. Thereafter the lower end of the outer shell is removed; the upper yoke is detached from the mandrel; and the tubes with the sealing assembly proper are withdrawn from the apparatus and taken to the laboratory or elsewhere for tests. Thus withdrawn, the assembly, in addition to the tubes containing the cores, includes the upper and lower yokes, the sealing plugs, the sealing cups and the center bolt. This assembly is light enough to be easily handled.

In the laboratory, the usual tests upon the cores are run with the assurance that the results will not be vitiated by contamination of the core samples or leakage therefrom.

To summarize the movements in the sampling operation just described, the stem with the coring equipment attached is lowered until the latter rests on the bottom of the hole. Some rotation during the lowering operation is permissible if desired, and circulation to the bottom of the hole is possible at any time.

In the second phase of the operation, all or part of the weight of the drill string is set on the bottom of the hole in order to cause the core tubes to penetrate the formation.

In the third stage of the operation, the drill string is raised until the coring device is off bottom. This permits the sealing cups to rotate into sealing position.

In the fourth operation, the tool is again set on the bottom, and the drill pipe is rotated 30 or 40 turns to cause the yokes to move closer together

and seal upper and lower ends of the coring tubes.

The fifth stage of the operation is merely the withdrawal of the drill string and the removal of the samples in the coring tubes.

I claim:

1. In apparatus for attachment to the bottom of a drill stem for taking a formation sample in the bottom of a drill hole, the combination which comprises a mandrel mountable on the bottom of the stem in alignment therewith, a shell slidably mounted upon the mandrel, rupturable means initially connecting mandrel and shell to prevent such sliding, a core barrel mounted on the bottom of the mandrel and having an open lower cutting end, and a closure member mounted on the shell and adapted to close the lower end of the core barrel when the mandrel is slid upward with respect to the shell.

2. In apparatus for attachment to the bottom of a drill stem for taking a formation sample in the bottom of a drill hole, the combination which comprises a mandrel mountable on the bottom of the stem in alignment therewith, a shell slidably mounted upon the mandrel, a core barrel mounted on the bottom of the mandrel and having an open lower cutting end and also an open upper end, a closure member mounted on the shell and adapted to close the lower end of the core barrel when the mandrel is slid upward with respect to the shell, and a sealing plug slidable in the bore of the core barrel.

3. In apparatus for attachment to the bottom of a rotary drill stem for taking a formation sample in the bottom of a drill hole, the combination which comprises a mandrel mountable on the bottom of the stem in alignment therewith, a shell slidably mounted upon the mandrel, a core barrel mounted on the bottom of the mandrel and having an open lower cutting end and also an open upper end, a closure member mounted on the shell and adapted to close the lower end of the core barrel when the mandrel is slid upward with respect to the shell, a sealing plug slidable in the bore of the barrel, a seat for the plug adjacent the top of the barrel, and clamping means actuated by rotating the drill stem for pressing the closure member against said lower end.

4. Apparatus according to claim 3 provided with a valve in the plug which is seated when a core is pushed upwardly in the barrel.

5. In apparatus for attachment to the bottom of a rotary drill stem for taking a formation sample in the bottom of a drill hole, the combination which comprises a mandrel mountable on the bottom of the stem in alignment therewith, a shell slidably mounted upon the mandrel, a core barrel mounted on the bottom of the mandrel and having an open lower cutting end, a closure member mounted on the shell and adapted to close the lower end of the core barrel when the mandrel is slid upward with respect to the shell, a threaded bolt attached to the closure member and extending up into a wrench bore of non-circular cross section on the axis of the mandrel, a nut slidable along the bore but rotatable thereby and threaded on the bolt, an upper yoke attached to the barrel and a lower yoke attached to the closure member with the bolt arranged to press the two yokes together when the nut is rotated, thereby pressing the closure member against the lower end of the barrel.

6. Apparatus according to claim 5 provided with a wrench sleeve of cylindrical section

mounted in a bore in the mandrel and containing the wrench bore, and shearable means connecting the wrench sleeve to the mandrel.

7. In apparatus for attachment to the bottom of a rotary drill stem for punching out and recovering a sample from the bottom of a drill hole, the combination which comprises a mandrel mountable on the bottom of the stem in alignment therewith, a sleeve mounted around the mandrel and slidable and rotatable with respect to the mandrel, rupturable means initially affixing the sleeve to the mandrel, at least one core barrel mounted on and below the mandrel in alignment therewith, and having an open lower cutting end and an open seat at its upper end, a sealing plug slidable upward in the core barrel to abut the seat, a closure member mounted on the sleeve to swing on an axis extending in the direction of the drill string to seal the lower end of the core barrel when it and the mandrel have slid upward sufficiently with respect to the sleeve, a spring for so moving the closure member and clamping means actuated through rotation of the mandrel and adapted to press the closure member upwardly against the bottom of the core barrel.

8. In apparatus for attachment to the bottom of a rotary drill stem for punching out and recovering a sample from the bottom of a drill hole, the combination which comprises a mandrel mountable on the bottom of the stem in alignment therewith, a sleeve mounted around the mandrel and slidable and rotatable with respect to the mandrel, rupturable means initially affixing the sleeve to the mandrel, an upper yoke attached to the mandrel, at least one core barrel mounted on and below the mandrel in alignment therewith, and having an open lower cutting end and an open seat at its upper end, a sealing plug slidable upward in the core barrel to abut the seat, a closure member mounted on a lower yoke attached to the sleeve to swing on an axis extending in the direction of the drill string to seal the lower end of the core barrel when it and the mandrel have slid upward suffi-

ciently with respect to the sleeve, a spring for so moving the closure member, a threaded bolt passing through both yokes and extending up into a wrench bore of non-circular cross section on the axis of the mandrel, and a nut slidable along the bore, but rotatable thereby and threaded on the bolt above the upper yoke, the bolt and yokes being so arranged that rotation of the mandrel causes the nut to press the yokes toward each other.

9. In apparatus for attachment to the bottom of a rotary drill stem for taking a formation sample in the bottom of a drill hole, the combination which comprises a mandrel mountable on the bottom of the stem in alignment therewith, a shell slidably mounted upon the mandrel, a core barrel mounted on the bottom of the mandrel and having an open lower cutting end, a closure member adapted to close the lower end of the core barrel when the mandrel is slid upward with respect to the shell, and clamping means actuated by rotating the drill stem for pressing the closure member against said lower end, said clamping means comprising a threaded bolt attached to the closure member and extending up into a bore of non-circular cross section in the mandrel on the axis thereof, a nut of corresponding cross section slidable in the bore and threaded on the bolt, an upper yoke attached to the barrel below the bolt, and a lower yoke attached to the closure member, the two yokes being so arranged that they are pressed toward each other by rotation of the nut on the bolt.

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