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(71) Applicant: **ORECO OILFIELD SERVICES LIMITED**
30-36 Virginia Street
Aberdeen AB1 2AU(GB)

(72) Inventor: **Coey, Raymond Paul**
St Ouentin, Brechin Road
Montrose DD10 9LE(GB)
Inventor: **Simpson, Neil Andrew Abercrombie**
Burn of Daff Farm, Downies
Portlethan, Aberdeen AB1 4OX(GB)

(74) Representative: **Pattullo, Norman**
Murgitroyd and Company 373 Scotland Street
Glasgow G5 8OA(GB)

(54) **Sidewall coring tool.**

(57) A tool (1) for obtaining rock samples during drilling, comprising a hole opener assembly or underreamer (2) for attachment to a drill string with a coring assembly (3) mounted in a recess in the body of the tool (1). The coring assembly (3) is mounted on the tool body (1) so that it can pivot (5) and be deployed at a shallow angle to the longitudinal axis of the tool body (1). The hole opener assembly or underreamer (2) forms a ledge around the tool body (1) and the coring assembly (3) performs a coring operation on the ledge. Alternatively, the coring assembly (13) performs a coring operation in the pocket formed by an underreamer (12) where the coring assembly (13) is mounted within a cutting arm (12a) of the underreamer (12).

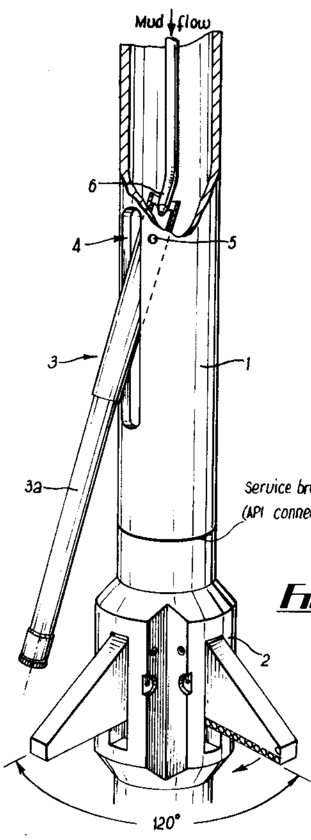

FIG.3

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This invention relates to a sidewall coring tool especially but not exclusively for use downhole in the petroleum drilling industry.

Coring is a known technology and has been carried out since Egyptian times. It has developed considerably and is today a very sophisticated process.

Coring is normally carried out to obtain rock samples for geological data. This is the case in both the mining and petroleum industries, where cores are normally taken concentric to the bore hole.

In mining, it is quite common to core the entire hole. These holes are of small diameter and relatively low cost their primary objective being to provide geological data.

This is not the case in the petroleum industry. The holes are much larger and more costly to drill. Their primary objective is to produce oil. Whilst the geological data is important, it is normally the secondary objective.

Consequently coring is only carried out in specific areas of interest, but of course it is extremely difficult to identify these areas accurately prior to coring. As a result considerable sections might be cord concentric to the well bore which prove of no interest whatsoever. Alternatively, the formation can continue to be drilled to the point of interest thereby losing valuable rock data.

As drilling is a high cost process it is desirable to be able to drill oil wells without carrying out costly and time consuming coring operations. At the same time however, the rock samples are still required for geological analysis.

It would be an ideal situation to be able to drill the well, identify the specific areas of interest, and then go back and core rock samples from these areas.

Previously proposed drilling and coring techniques have not been able to provide adequate core samples however, while at the same time avoiding disrupting the drilling operation.

According to the present invention there is provided a sidewall coring tool comprising a main body having means at either end for attachment to a drill string characterised in that the tool has an underreamer or hole opener assembly having a plurality of circumferentially arranged cutter arms and a coring assembly, the coring assembly being pivotally mounted on the main body and being arranged such as to be deployable at an angle to the longitudinal axis of the tool body, the underreamer being arranged to selectively perform an underreaming operation to form an annular ledge in a formation around the tool, so that the coring assembly when deployed performs a coring operation on said ledge.

The coring assembly may alternatively be mounted within the body of an underreamer cutter arm and arranged for deployment in the pocket formed by the underreamer.

Preferably hydraulic means are provided for operating the underreamer assembly. This may for example be a special adapter above the cutter arms.

The means for deploying the coring assembly may be mechanical or hydraulic.

Preferably means are provided for supporting the coring assembly in its deployed position.

Preferably a plurality of coring assemblies are provided spaced circumferentially around the tool body.

Most preferably means are provided for selectively deploying the coring assemblies.

Preferably also couplings are provided on the coring assemblies to receive hydraulic drive means.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Fig. 1 is schematic representation of a sidewall coring tool in accordance with the present invention;

Fig. 2 is a schematic representation of a sliding joint and drive mechanism of a sidewall coring tool in accordance with the present invention;

Fig. 3 is a perspective view of a first embodiment of a sidewall coring tool in accordance with the present invention.

Fig. 4a is a sectional view of the coring assembly of the tool of Fig. 3 immediately following deployment;

Fig. 4b is a sectional view corresponding to Fig. 4a illustrating the coring assembly in operation;

Fig. 5a-e are schematic plan views illustrating five successive stages in operation of the tool;

Fig. 6 is a perspective view of a second embodiment of a sidewall coring tool in accordance with the present invention;

Fig. 7 is a larger scale schematic of part of a sidewall coring tool of the type illustrated in Fig. 6 illustrating the core sample tragectory;

Fig. 8 is a sectional view of part of the tool of Fig. 6 illustrating the operation of the cutter arm and coring assembly of the tool; and

Fig. 9 is a schematic view illustrating further aspects of the operation of the tool of Fig. 6.

Referring to the drawings the general concept and principle of operation will first be described with reference to Fig. 1 and 2. Subsequently particular examples of tools embodying these general concepts will be described with reference to Figs. 3 to 9.

In principle the Sidewall Coring Tool (SCT) is intended to provide a means of taking multiple cores from areas of geological interest, either in one selected region or in individual areas to the maximum number of cores available, or a combination of both.

It is envisaged that one or more coring assemblies will be embodied near or within a specially designed underreamer or hole opener and that the coring operation will be performed, either:

a) from specially deployed individual assemblies located in windows or "garages" within the main body of the tool set between and preferably above the level of the underreamer cutter arms, or

b) through the body of specially designed cutter arms, such that the coring head will be deployed somewhere in the underreamed pocket.

Other means of deploying the coring head exist, but coring onto a distinct ledge provides cores outwith the mud invasion layer yielding good quality rock samples, and this is therefore the preferred method. The cores are typically between 5' to 10' in length. However, it is conceivable that core samples very much longer or shorter than this might be achieved.

It will also be appreciated that the means of taking a core from the wall of a well may vary, but the two operations outlined above provide particularly effective means of doing so.

It is intended that the SCT will be operated in holes of 12.25" (opened to 17.50") and 8.50" (opened to 12.25"). The SCT will be connected to the drillstring in the normal manner using API (American Petroleum Institute) recommended connections.

General details of the garaged type design will now be described. The SCT consists of an underreamer attached to the drillstring directly beneath the coring assemblies. Preferably there will be a service break (using locking threadforms) between the SCT and the underreamer. This will ensure an angular offset between the location of each core barrel and the cutter arms of the underreamer.

The drillstring will be connected and run downhole in the normal manner until the depth specified for coring. During this time, both the underreamer and SCT will remain inert, unable to deploy their respective systems until activated from surface. The cutter arms will therefore remain within the body of the underreamer, and the coring assemblies captive within the wall of the SCT.

When the appropriate hole depth has been reached, preferably some hydraulic means will be used to deploy the cutter arms from the underreamer. This can be accomplished by running a hydraulic coupling into a special adapter above the cutter arms. The hydraulic pressure then applied from surface will deploy the cutter arms to their maximum position during the underreaming operation.

Once the underreaming operation has stopped, the full weight below the underreamer may be set down via the cutter arms onto the ledge that has been cut. The hydraulic coupling may now be retracted and withdrawn to an arbitrary datum position located above the level of the drive(s) to the core barrel(s).

When the hydraulic coupling has been withdrawn past the level of the drive(s) to the core barrel(s), a hydraulic or mechanical mechanism selectively deploys one of the core barrel assemblies into the space between two of the cutter arms. Preferably some level of support for the length of the coring assembly will be provided.

The core barrel assembly is deployed from its captive position in the wall of the SCT about hinge pins which act as the fulcrum point and are set close to the core barrel drive. Preferably the hinge pins will not interfere with the bore of the core barrel or its drive mechanism, but will be retained within the wall of the SCT and be externally flush.

The hydraulic coupling is now run forward to engage the drive of the core barrel which has been canted into the bore of the SCT. Preferably the operational angle is shallow, being constrained to a maximum of about 5 degrees. The means of engagement may be made easier by enabling the drive on the hydraulic coupling to find the drive in the core barrel by providing a lead-in or bell-mouth aperture in the core barrel.

Necessarily the core barrel drive will be a simple, robust device capable of readily applying tensile and compressive forces, and torque. The hydraulic coupling and drive shaft will engage the core barrel drive for the duration of the coring exercise. Mud will be circulated through the hollow drive shaft, through the drive and core barrel to the coring head to provide adequate cooling and debris removal during operation.

The compressive load and torque will be applied during the coring operation as the core is being cut. The tensile load will be applied when the cutting of the core is finished and the rock sample must be broken. The tensile load will be maintained until the core barrel has been retracted within the guide sleeve. Given that the coring is carried out at a shallow angle, the flexural fatigue of the hydraulic coupling and drive shaft is not a problem, and is well within the angular distortions already successfully applied to standard downhole equipment.

Once the core barrel has been fully retracted within the guide sleeve, the hydraulic coupling and drive shaft may detach and withdraw to its datum position in anticipation of further coring exercises, should this be required.

The core barrel assembly deploying mechanism may now be deactivated such that the full assembly is returned to its captive position in the wall of the SCT. The deployment/redeployment actuating mechanism will provide the means to index the "garages" of the SCT (or access to the "garages") to ensure that:

(i) a used core head and core barrel assembly are never re-used,

and

(ii) the formation cored is sufficiently displaced (in an angular sense) from that already cored, to enable geologists to make a good appraisal of the stratigraphic features of the region.

However, as stated above, the multiple "garage" principle permits cores to be cut from various depths within one trip. The number of cores cut on any trip is of course limited by the number of "garaged" core barrel assemblies which can be successfully incorporated within the wall of the SCT. For different applications this may vary.

The general operating concept of the integral type design will now be described. In this instance, the SCT consists of coring assemblies physically incorporated within the material of the cutter arms of an underreamer. The cutter arms will necessarily be much longer than those used normally. The excess length is due to the shallow angle of operation required when coring, where it is anticipated that the angle will be constrained to about 5 degrees maximum.

The drillstring will be connected and run downhole in the normal manner until the SCT reaches the depth specified for coring. In keeping with traditional technology, the SCT will remain inert, unable to deploy the cutter arms until activated from surface. The cutter will therefore remain within the main body of the underreamer, and the coring assemblies remain captive within each cutter arm.

When the appropriate hole depth has been reached, preferably some hydraulic means will be used to deploy the cutter arms from the underreamer. Typically, this may be achieved using the principle of differential cross-sectional areas across the length of a piston.

As hydraulic pressure is applied to the fluid in the drillstring by the surface pumps, the actuating piston is displaced axially, possibly compressing a heavy duty return spring. As the actuating piston moves downwards, a mechanism (possibly a linkage) attached to the lower part of the cutter arm, forces the arm to rotate on its hinge pin and move outwards. Combined with rotation of the drillstring, the cutter arms will open (or underream) a short section of the hole.

It must be noted that because the coring assemblies are retained within the material of the cutter arms, some means of positive retention is employed to ensure that they cannot slide out arbitrarily. This retention mechanism has two distinct purposes:

(i) To provide a positive means of retention of the core barrel assembly before and after the coring operation takes place. This will require some means of latching and unlatching the assembly.

(ii) To retain the coring assembly during the underreaming operation such that the shock loads and vibration generated during cutting cannot hinder deployment of the coring assembly or indeed cause the premature deployment of the coring assembly.

Similarly, the short section between the end of the core head and the bottom of the cutter arm may be packed with wax (or similar drillable plug material) to prevent the ingress of rock debris and cutting fluid during the underreaming cycle.

Once the underreaming operation has been completed, the full weight of the drilling assembly below the tool may be set down via the cutter arms onto the ledge that has been cut. The cutter arms will be held open by the arm geometry, that is the centre point of load will be outside centre of rotation, creating a geometric lock 2eld in place by the downward force of the assembly weight below the tool. This load will be too great for the return spring to overcome and the hydraulic pressure applied in the first instance may now be released if necessary.

A hydraulic coupling and drive may now be deployed from its datum point where it has remained inert. The hydraulic coupling and drive is run down through the internal bore of the actuating piston until it contacts an angled ledge or step located in one position only in the bore. This ledge will be sufficient to deflect the coupling into the long elliptical opening directly opposite to engage the drive of the core barrel. It is intended that the core barrel drive mechanism is a relatively simple device which will readily apply tensile and compressive forces, and torque.

The hydraulic coupling and drive shaft will engage the core barrel drive for the duration of the coring exercise. Mud will be circulated through the hollow drive shaft, through the drive and core barrel to the coring head to provide adequate cooling and debris removal during operation.

Once the coring exercise has been completed, a tensile load is applied through the core barrel drive to break the rock sample and retract the core assembly within the cutter arm. The assembly will be retracted sufficiently to latch onto the core barrel retention mechanism described above. Once this occurs, any further application of a tensile load will disengage the drive mechanism and retract the hydraulic coupling and drive from the cutter arm into the core of the actuating piston, thence to its datum point.

After the hydraulic coupling and drive has been retracted to its datum position, the orientation of the angled ledge or step in the actuating piston bore must change to ensure that the hydraulic coupling and drive may only engage a virgin coring assembly. To achieve this, the applied pressure of the surface pumps may be reduced or removed, and the drill assembly then lifted off the under-reamed shoulder where it has been hanging. This will be sufficient to allow the heavy duty return spring to drive the actuating piston to its datum position.

If pressure is applied once more by the surface pumps, the actuating piston will move down and deploy the cutter arms of the underreamer as before. However, as the actuating piston moves down under the pressure, it may index on a mechanism (possibly a J-slot configuration) which rotates it through an angle which orients the angled ledge or step to a position opposite the aperture of a virgin coring assembly.

As an addition, it may be advantageous to block completely the means of entry into those coring assemblies that are used. This would stop the ingress of contaminants onto the core sample during circulation, for example.

Alternatively, the access to each core barrel drive may be completed by the return spring. The applied pressure of the surface pumps would be reduced or removed as above, and the drilling assembly lifted off the underreamed shelf where it has been hanging. As the return spring then tends to its free length, the actuating piston is driven up the bore of the SCT towards its datum position. As it goes, it may index through the required angular displacement such that it is pre-positioned for the next coring run. It is recognised that alternatives to the two methods outlined here exist, and may be produced as alternative designs.

The SCT incorporating coring assemblies within the cutter arms(s) of the underreamer permits relatively long rock samples to be taken outwith the mud invasion zone using the underreamer arms as the means of support. In effect, the bore of the cutter arms acts like a gunbarrel for the coring assembly, and except for rotation of the drillstring during coring it is very difficult to destroy the coring assembly in operation.

The drive mechanism used in both systems described above is run in from an arbitrary datum to engage in the drive of the coring assembly.

The hydraulic coupling and drive (which are an integral unit) may be incorporated in a type of telescopic joint. Such a joint may be based around a standard drill collar modified to accept a polished joint sliding through it. The overall length of the assembly is sufficient to enable the full traverse of the sliding joint to take the required length of core sample.

The sliding arm of the telescopic joint may be connected to the drillstring in the normal manner using standard API recommended threadforms. The external surface of the sliding joint necessarily requires some degree of polish to enable it to slide easily through the gland packing material located in the top of the modified drill collar.

The sliding joint may require a splined end to engage with a similar spline machined internally in the modified drill collar. In this way, rotation of the drillstring would impart torque to the cutting arms of the underreamer. Beneath the splines, it would be necessary to attach the hydraulic coupling and drive. This may be a relatively long, but slender hollow tube, adapted at the drive end to permit it to impart torque to drive the coring assembly and also tensile and compressive loads.

As the sliding joint moves down within the modified drill collar, it may be possible that the fluid displaced will be forced through a small hole or aperture into a large reservoir. This would in effect be a safety mechanism in the event of underreamer failure or dislodgement. Fluid could only be displaced from the reservoir as swiftly as the aperture would permit.

The telescopic joint method of applying drive may be readily withdrawn after the core has been taken by pulling up slowly at the rotary table. The tensile load would break the core rock sample and withdraw the coring assembly to either its "garaged" position in the "garaged" design or within the body of the particular cutter arm in the "integral" design.

Referring now to Fig. 3 to 9 further details of simplified examples of sidewell coring tools operating as described above will now be given. In Fig. 3 to 5 details of the garaged type device are shown. The tool comprises a hollow tubular body 1 which is connected to an underreamer device 2 of generally know type. A coring assembly 3 is positioned within an aperture 4 in the body 1 and mounted on a pivot 5. In its retracted or non deployed position the coring assembly fits within the aperture 4 so as not to interfere with the normal drilling operation or underreaming operation. In its immediately deployed position, as shown in Fig. 4a, the coring assembly extends at a shallow angle, in this case 3.5 degrees maximum, but other angles are possible. After the underreamer 2 has operated, as described above, the coring assembly 3 extends, as in Fig. 3, and effectively carries out a coring operation as shown in Fig. 4b where a core barrel 3a extends from the coring assembly 3. At the upper end of the coring assembly 3 a hydraulic coupling 6 provides a drive means and a conduit for mud flow. This particular example shows only a single coring assembly but, as described above, a number of such assemblies may be provided.

Fig. 5a to 5e show various stages in the operation of the tool. In Fig. 5a the tool is inactive with neither the underreamer 2 nor the coring assembly or assemblies 3 being activated. In Fig. 5b the underreamer is brought into action to create the ledge into which the coring assembly 3 may be advanced. Following the underreaming operation the weight is taken on the underreamer arms, the hydraulic coupling retracted and the coring assembly 3 is deployed as shown in Fig. 5c. As shown in Fig. 5d the coring operation is carried out and the assembly then retracted back to its original position. Finally as in Fig. 5e the core sample is parked and another core assembly 3, if more than one is included, may selectively be deployed.

Referring now to Figs. 6 to 9 details of the integral type tool are shown. In this embodiment an underreamer assembly 12 has cutter arms 12a which contain coring assemblies 13. Fig. 7 shows schematically the core barrel tragectory and Fig. 8 shows the deployment of a core barrel 13a of the coring assembly 13 following deployment of the cutter arms 12a. The cutter arms 12a are driven outwardly by virtue of a linkage 14 attached to a piston 15 which is driven downwardly against a return spring 16 by hydraulic pressure. Following release of the pressure the return spring forces the piston back up to retract the cutter arm 12a. Further details of the operation of the tool have already been described and it most be understood that the examples shown are by way of illustration only to provide a simple pictorial representation of the tool function.

Modifications and improvements may be incorporated without departing from the scope of the invention.

Claims

1. A sidewall coring tool comprising a main body (1) having means at either end for attachment to a drill string characterised in that the tool has an underreamer or hole opener assembly (2) having a plurality of circumferentially arranged cutter arms (2a) and a coring assembly (3), the coring assembly (3) being pivotally mounted (5) on the main body (1) and being arranged such as to be deployable at an angle to the longitudinal axis of the tool body, the underreamer (2) being arranged to selectively perform an underreaming operation to form an annular ledge in a formation around the tool, so that the coring assembly (3) when deployed performs a coring operation on said ledge.

2. A sidewall coring tool as claimed in Claim 1 wherein a plurality of coring assemblies (13) are mounted within the body of an underreamer cutter arm (12a) and arranged for deployment in the pocket formed by the underreamer (12).

3. A sidewall coring tool as claimed in Claim 1 wherein a plurality of coring assemblies (3), are provided spaced circumferentially around the main body (1) and arranged between respective cutter arms.

4. A sidewall coring tool as claimed in Claim 1, 2 or 3, wherein hydraulic means are provided for operating the underreamer assembly (2, 12).

5. A sidewall coring tool as claimed in any one of the preceding claims, wherein the coring assembly (3, 13) is deployed mechanically or hydraulically (6).

6. A sidewall coring tool as claimed in any one of the preceding claims, wherein means are provided for supporting the coring assembly in its deployed position.

7. A sidewall coring tool as claimed in any one of the preceding claims wherein, means are provided for selectively deploying the coring assembly or assemblies (3, 13).

8. A sidewall coring tool as claimed in any one of the preceding claims wherein couplings are provided on the coring assembly or assemblies (3, 13) to receive hydraulic drive means (6).

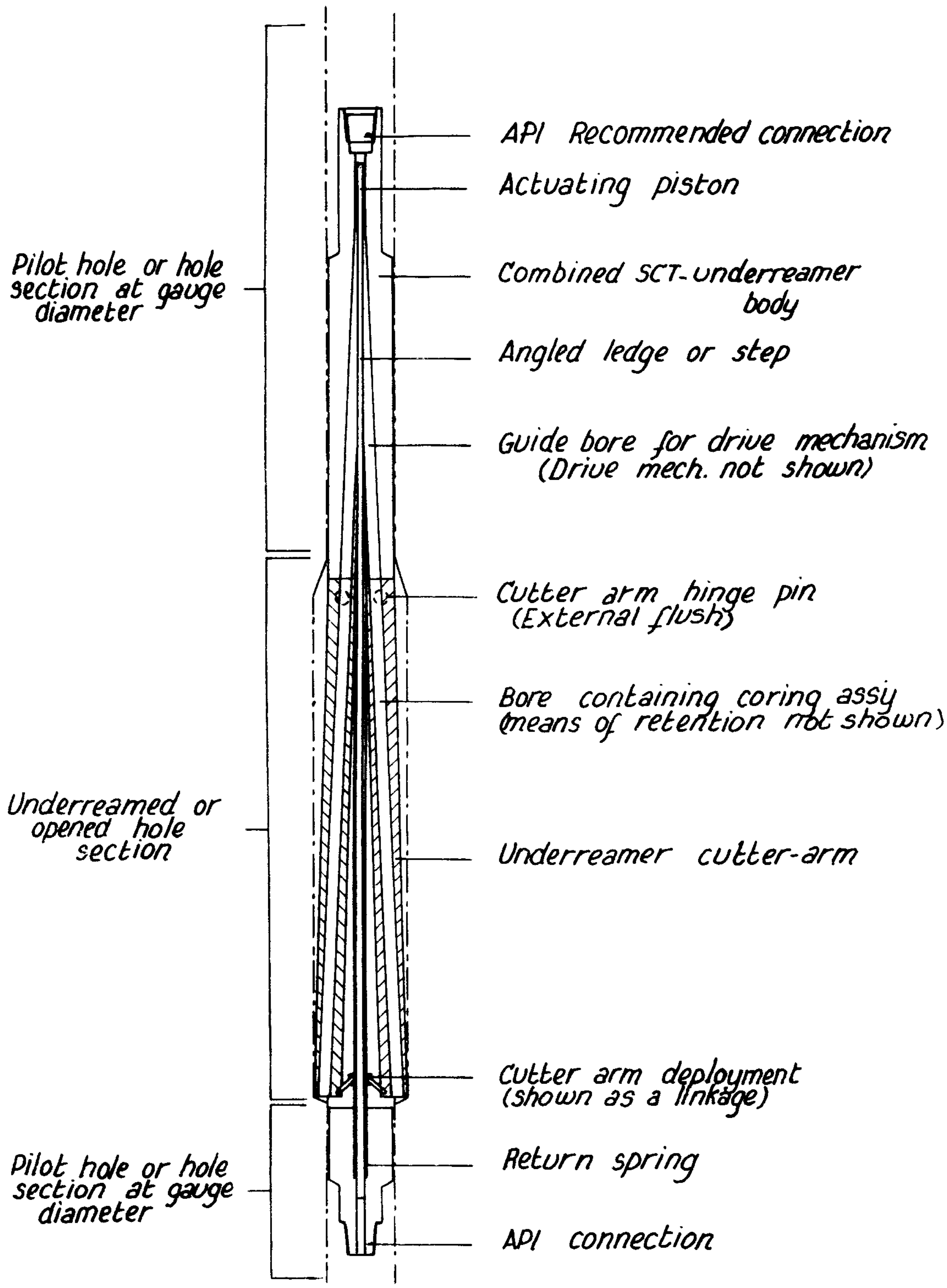
API Recommended connection
Actuating piston
Combined SCT-underreamer body
Angled ledge or step
Guide bore for drive mechanism (Drive mech. not shown)
Cutter arm hinge pin (External flush)
Bore containing coring assy (means of retention not shown)
Underreamer cutter-arm
Cutter arm deployment (shown as a linkage)
Return spring
API connection
Pilot hole or hole section at gauge diameter
Underreamed or opened hole section
Pilot hole or hole section at gauge diameter

FIG.1

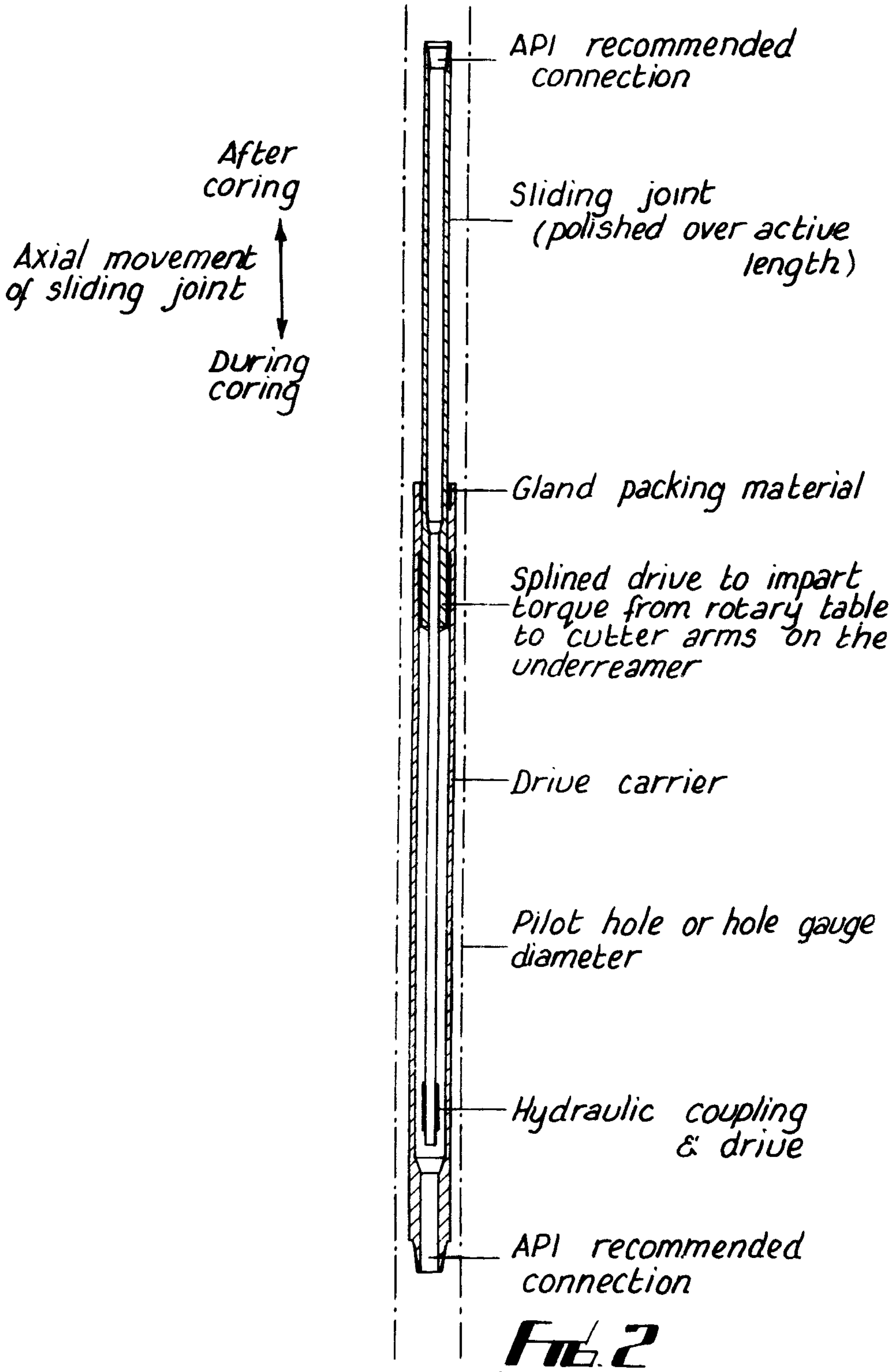
API recommended connection
After coring
Axial movement of sliding joint
During coring
Sliding joint (polished over active length)
Gland packing material
Splined drive to impart torque from rotary table to cutter arms on the underreamer
Drive carrier
Pilot hole or hole gauge diameter
Hydraulic coupling & drive
API recommended connection

FIG. 2

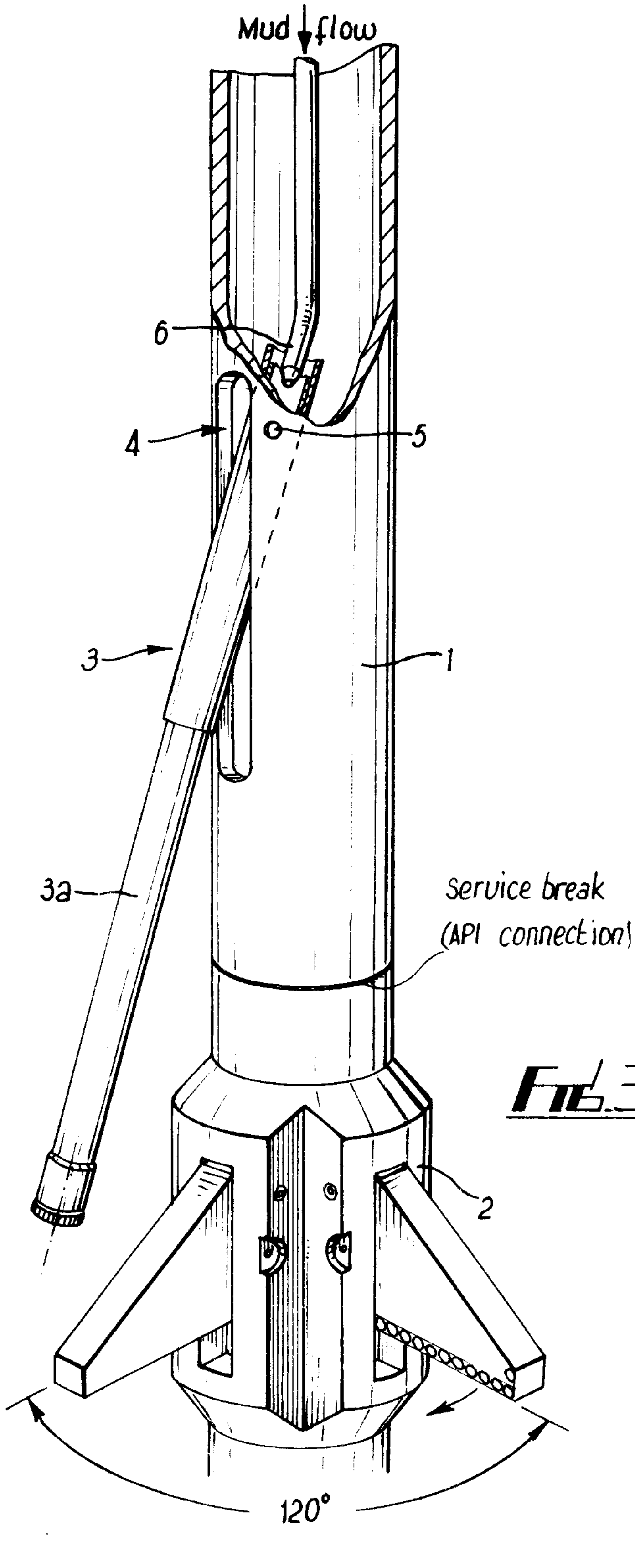

Fig. 3

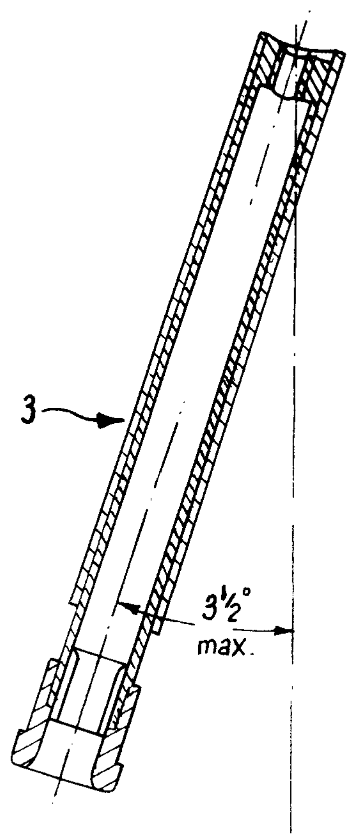

FIG.4a

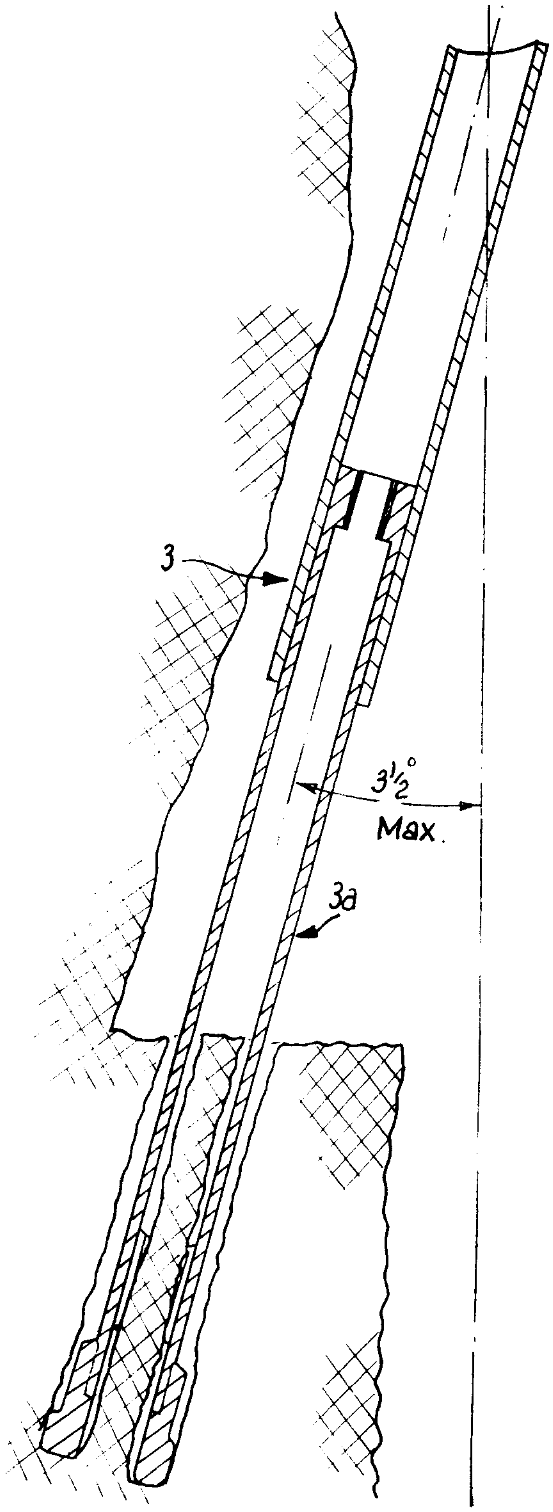

FIG.4b

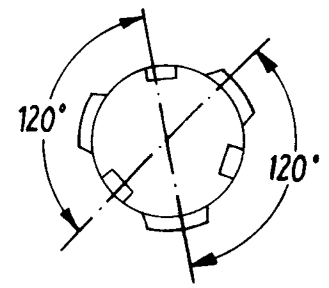

FIG. 5a

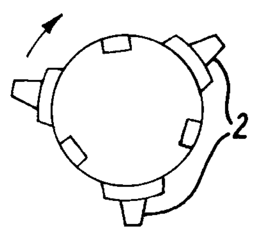

FIG. 5b

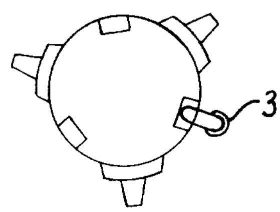

FIG. 5c

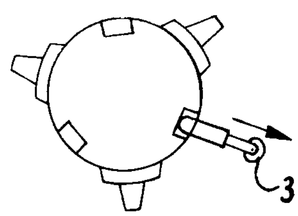

FIG. 5d

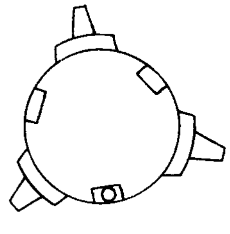

FIG. 5e

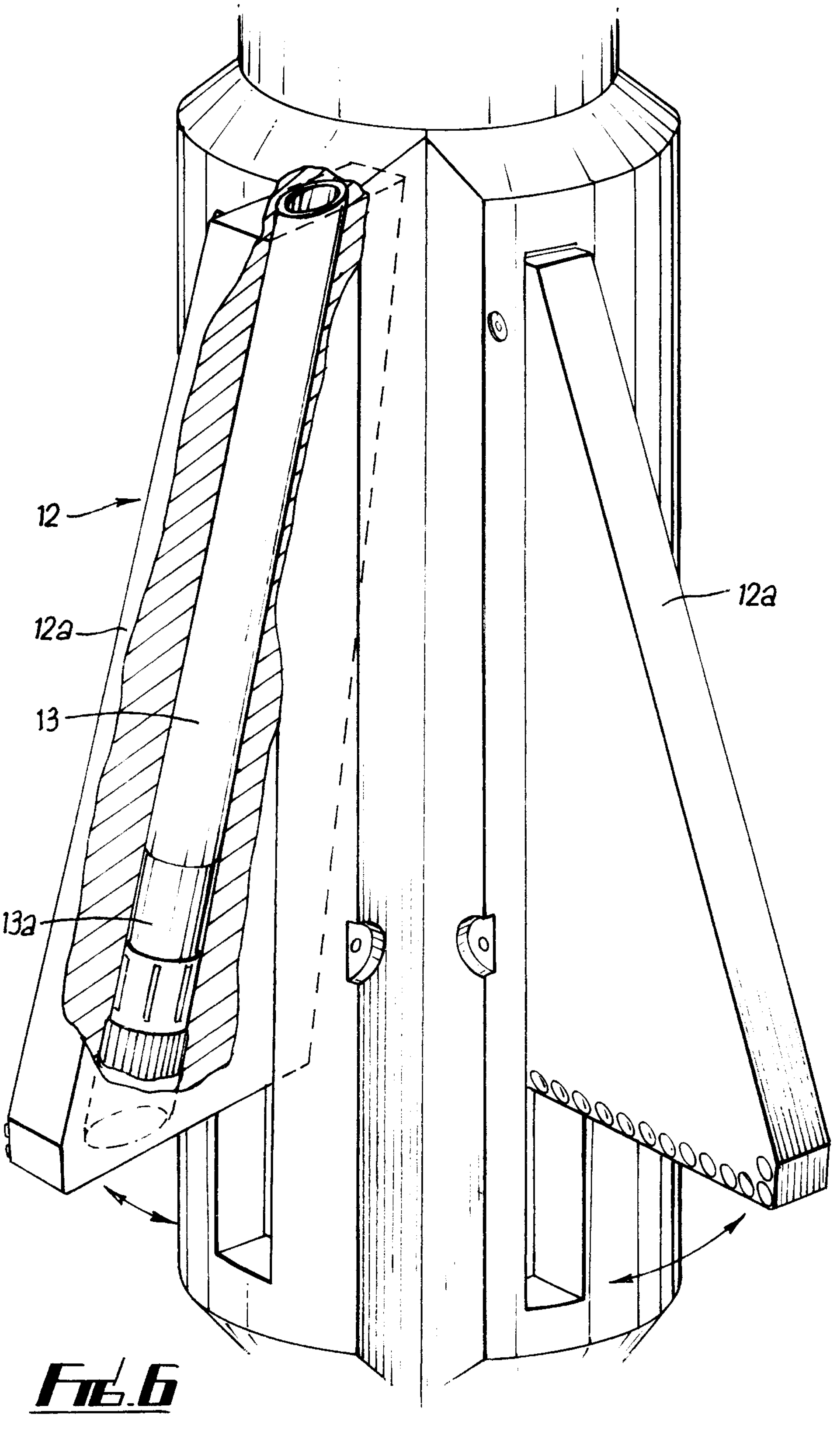

FIG.6

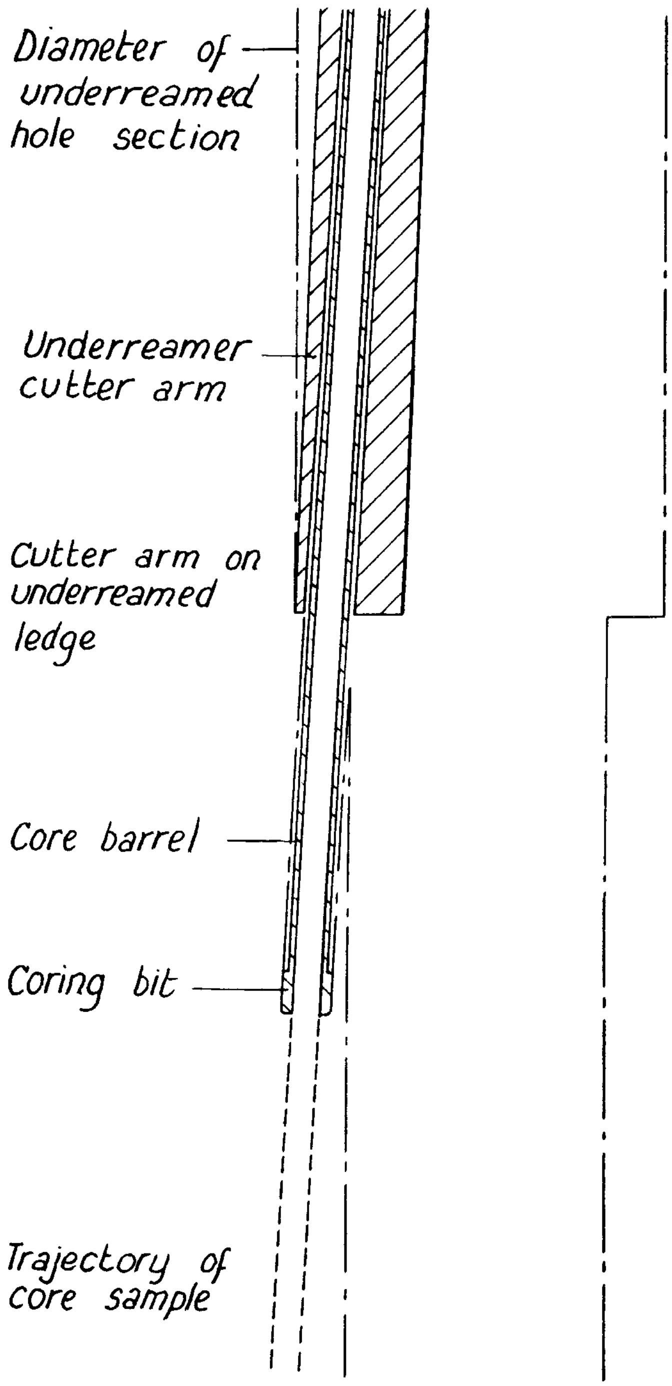
Diameter of underreamed hole section
Underreamer cutter arm
Cutter arm on underreamed ledge
Core barrel
Coring bit
Trajectory of core sample

FIG. 7

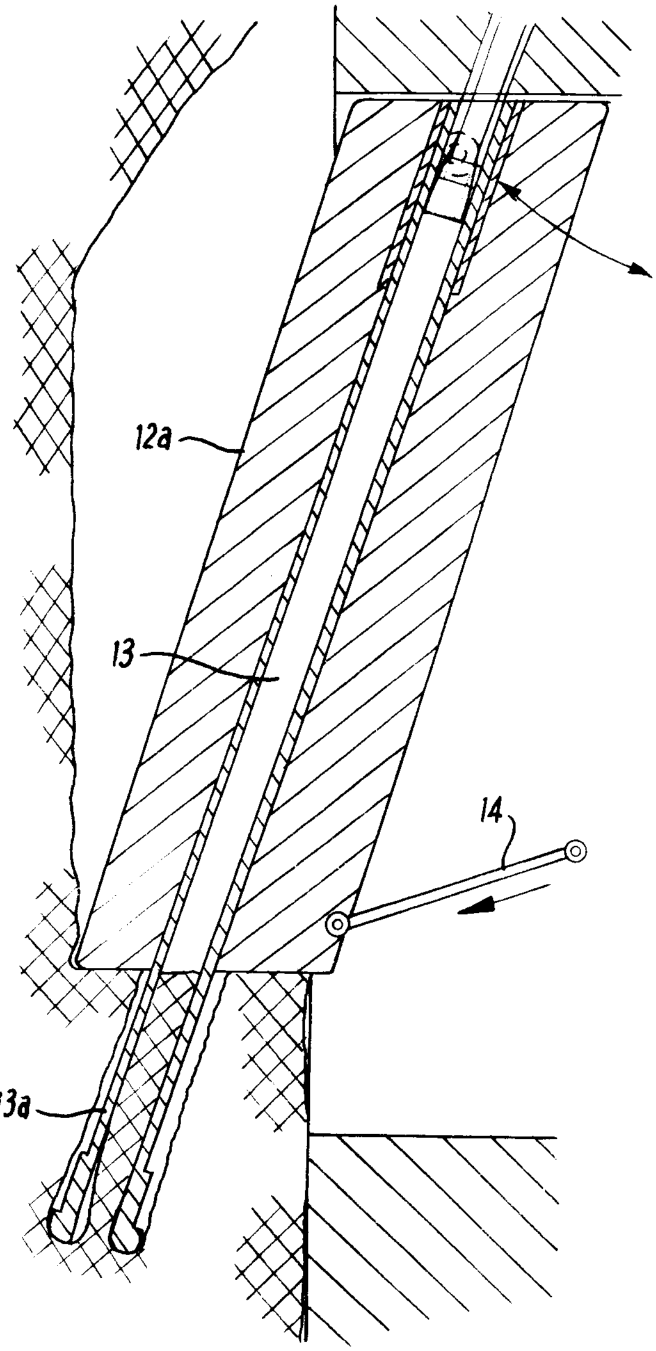

FIG.8

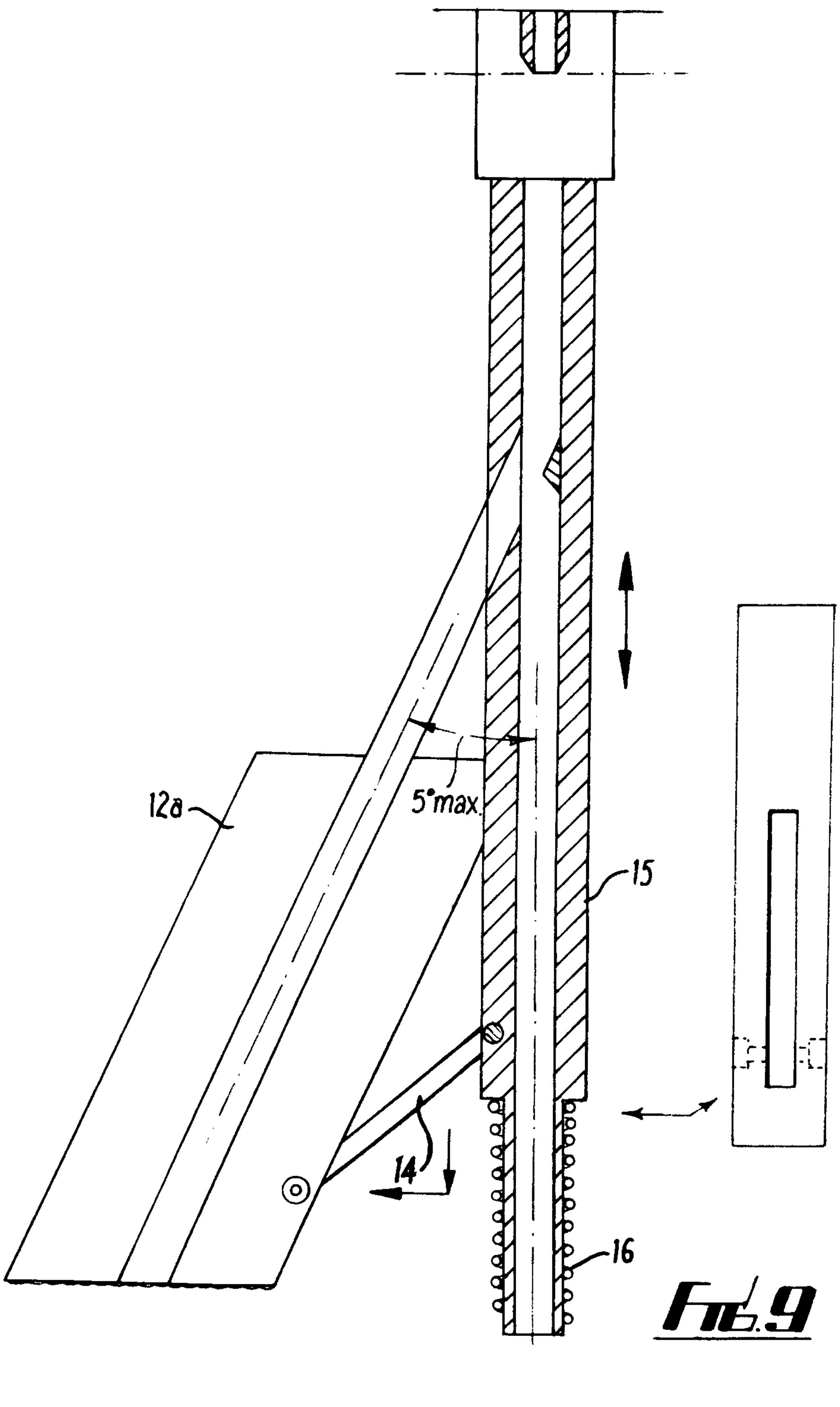

FIG.9

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 92306047.9

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US - A - 2 511 508 (CLINTON) * Fig. 1 * --	1,5	E 21 B 49/06
A	US - A - 3 150 727 (GARRISON) * Fig. 10-16 * --	1	
A	US - A - 3 598 191 (BULLARD) * Fig. 1 * --	1-3	
A	US - A - 4 461 360 (MOUNT) * Fig. 1 * ----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			E 21 B 49/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	29-10-1992	BENCZE

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document