RESEARCH ON THE COAL BENEATH THE NETHERLANDS

IV-NEW PRODUCTION METHODS

3. DIRECTIONAL DRILLING[1]

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ABSTRACT

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The practice of directional drilling in the petroleum industry is explained. It is shown that the drilling of horizontal boreholes of a few hundred meters is technically feasible. Measuring-while-drilling techniques have been developed and experiments are carried out towards achieving 'steered' drilling.

The experience in drilling for oil and gas is that holes are never straight. The resistance and the attitude of the various formations penetrated force the drillbit to deviate in direction (Fig. 1a). By using drillcollars and stabilizers on these drillcollars drillers can counteract these tendencies and they can also make use of these devices to achieve a required deviation from the vertical.

It may by said that all holes deviate from vertical; in so called straight drilling a certain deviation from vertical is accepted, in directional drilling the deviation is planned along a certain trajectory to reach a certain target (Fig. 1b).

Wells have been drilled directionally for many years, sometimes because of difficulties in finding suitable well locations above the target, sometimes in order to bypass broken-off tools (fishes) or to drill relief wells to kill wild blowing wells (Fig. 2). In offshore development many holes must be drilled from one platform in different directions because of the very high daily cost of the rigs. This has greatly contributed to improvements in the techniques of directional drilling whereby the emphasis was placed on reducing the duration of the very time consuming parts of the operation.

The operation, as shown in Fig. 3, consists of: (a) drilling a straight section, (b) using a deflection tool to 'kick off' from vertical in the right direction, (c) 'building up angle' until

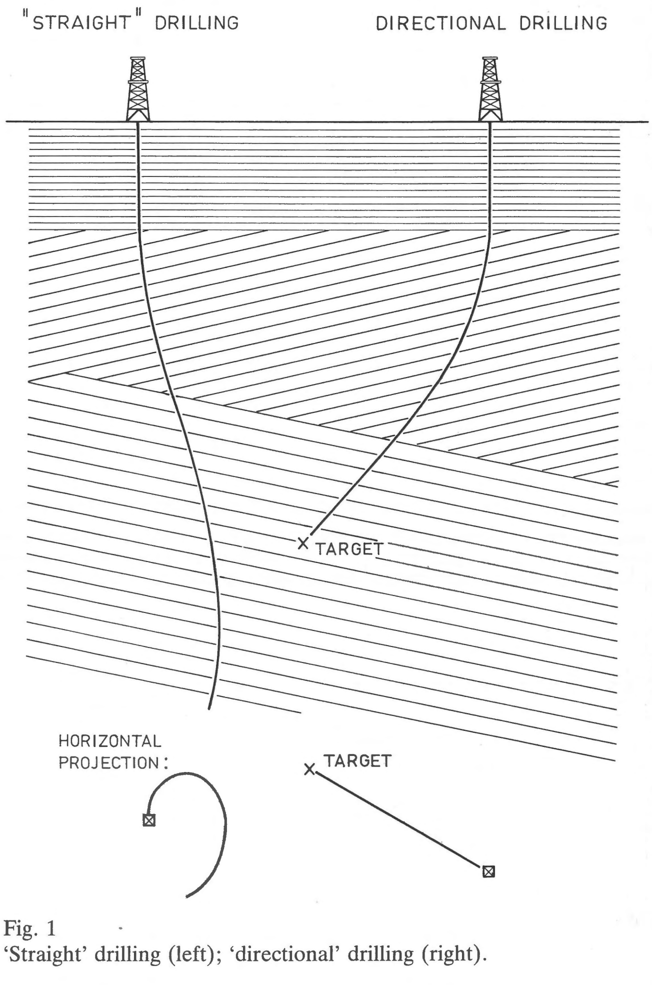

Fig. 1
'Straight' drilling (left); 'directional' drilling (right).

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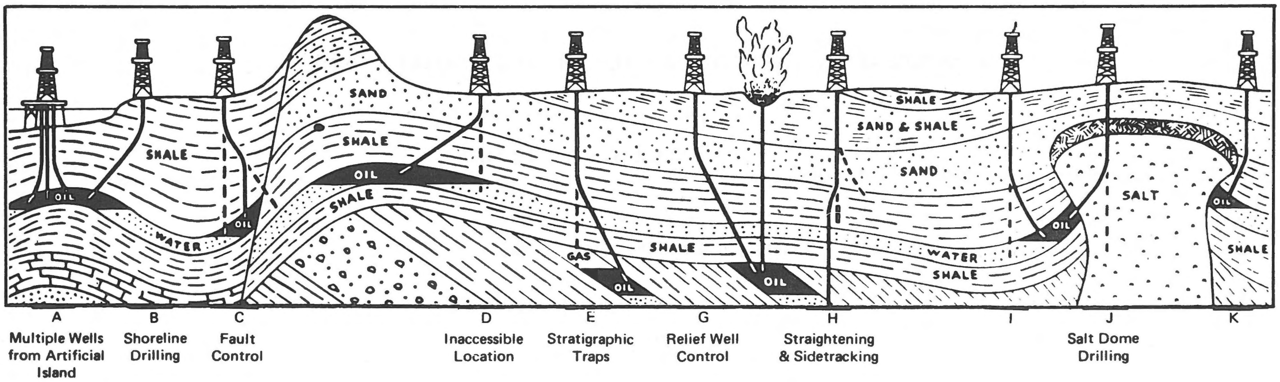

Fig. 2
Applications of controlled directional drilling (after Eastman catalogue).

sufficient deviation from vertical is obtained to reach the target and (d) drilling the straight section of the hole called the 'tangent section'. At many points along the hole surveys must be made and, if the hole wanders off the preplanned path, corrections must be applied.

If the target is shallow, 'slant hole drilling' can be carried out with rigs specially designed for this purpose (Fig. 4).

Deflection tools most commonly used in the past were the 'whipstock' (Fig. 5) and the 'spud bit' (Fig. 6).

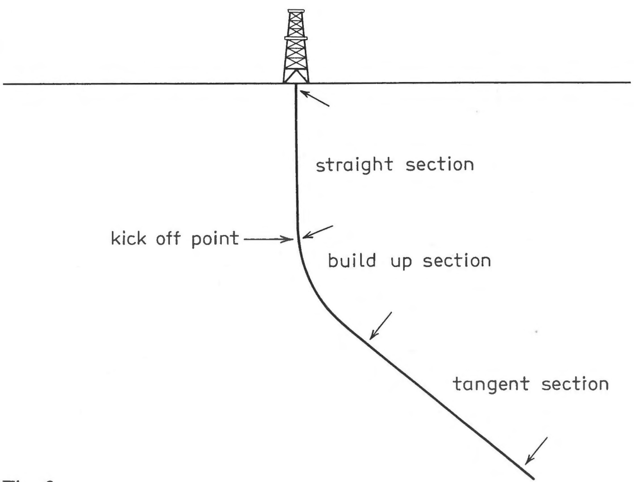

Fig. 3
Conventional directional drilling.

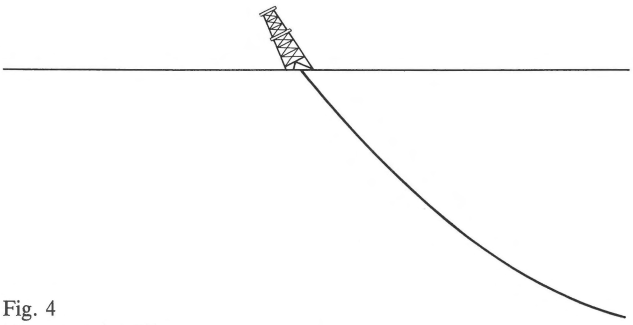

Fig. 4
'Slant hole' drilling.

The use of a whipstock was rather time consuming because it required a number of operations (Fig. 5): (1) Setting and orientating in the right direction. (2) Drilling off a short distance. (3) Pulling out. (4) Opening or widening the hole with a special hole opener. Repetition of all these operations was often necessary as the obtained deviation from vertical was seldom sufficient.

Spud bits (Fig. 6) could only be used in rather soft formations. By closing off all but one opening (nozzle) in the bit a stream of mud was emitted (jetted) with great force to one side of the hole. By simultaneously moving the bit up and down without rotation (spudding) a deflection from vertical was obtained. Proper orientation of the spud bit was rather difficult and often a great number of surveys were required to ensure that the hole kicked off in the right direction.

Whipstock and spud bit have completely been replaced by the turbine or mud-motor with a bent sub between turbine and drillcollars (Fig. 7). The use of this assembly as a deflection tool reduced the time required to get a kick off. After orienting the tool in the right direction the drill string is held

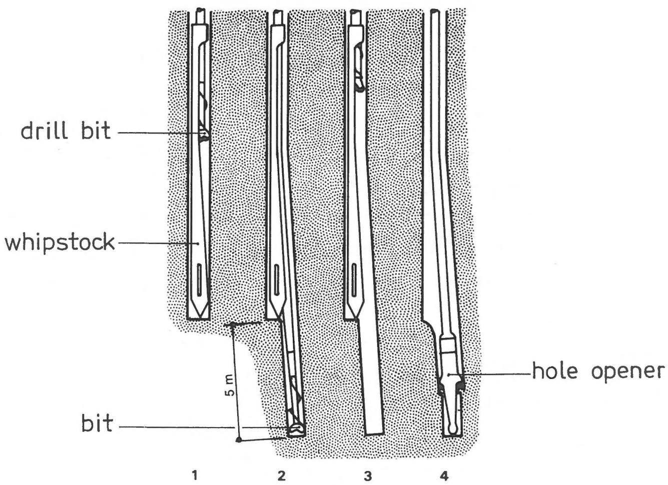

Fig. 5
'Whipstock'. 1. Setting and orienting. 2. Drilling off. 3. Pulling out. 4. Opening the hole with a hole opener.

stationary. Mud pumped down the drillpipe turns the rotor of the turbine with the bit connected to it. This can be continued until sufficient deviation from vertical in the right direction is obtained. The deflection tool can then be pulled out and the angle can be built up further by drilling with an assembly of drill-collars and stabilizers.

There are assemblies for building up angle (Fig. 8A) but the angle can also be held by an assemby with several stabilizers (Fig. 8B). It is even possible to place the stabilizers in such a position that the angle drops (Fig. 8C). By selecting the right assembly the build up and tangent section of the hole can be drilled.

Surveys must be made at regular intervals and a survey must not only show the deviation from vertical but also the direction of the hole. This can be done by using a single shot directional survey instrument (Fig. 9). This instrument is run inside the drill string on a wire line and as a magnetic compass is used it must be let down into a special non-magnetic drillcollar. This drillcollar is placed just above the bent sub

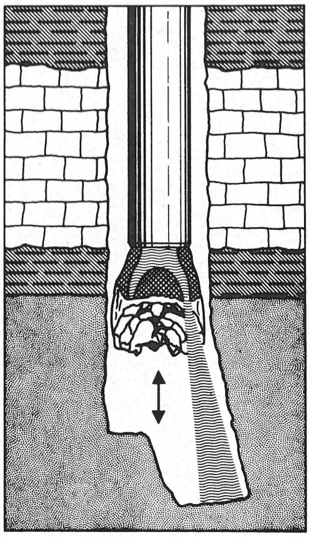

Fig. 6
'Spud bit'. Mud emitted ('jetted') with great force to one side of the hole while simultaneously moving the bit up and down ('spudding').

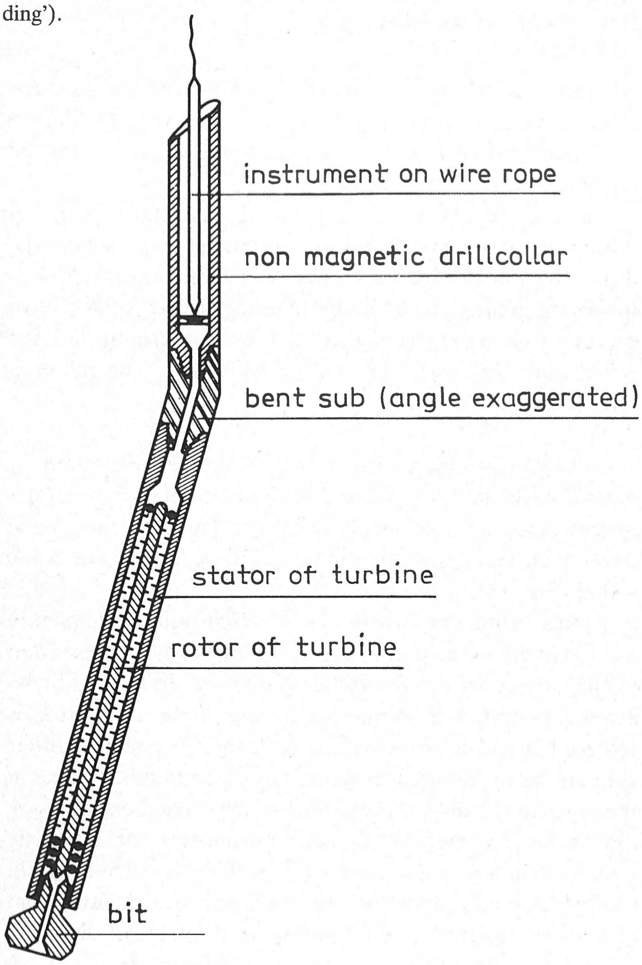

Fig. 7
Turbine with 'bent sub'. By pumping mud through the turbine the bit turns and drills in the required direction. The drill string is held stationary after orienting. At regular intervals the result can be checked by running a survey instrument on a wire rope.

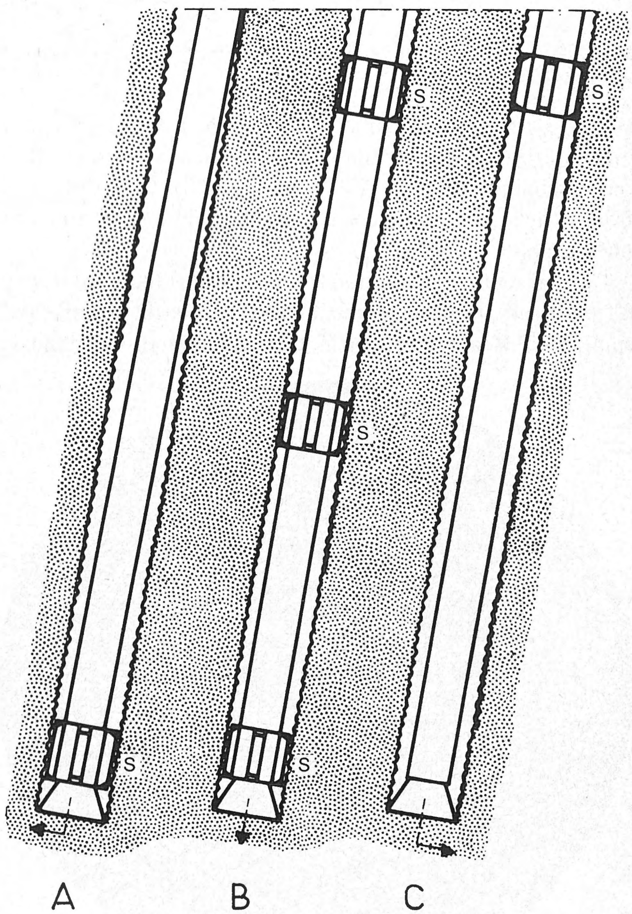

Fig. 8
Assemblies of 'drillcollars' and 'stabilizers' (S).
A. Assembly to build up angle; stabilizer located near bit.
B Assembly to maintain angle; several stabilizers to keep drillcollars straight.
C Assembly to drop angle; stabilizer placed higher in drillcollar string.

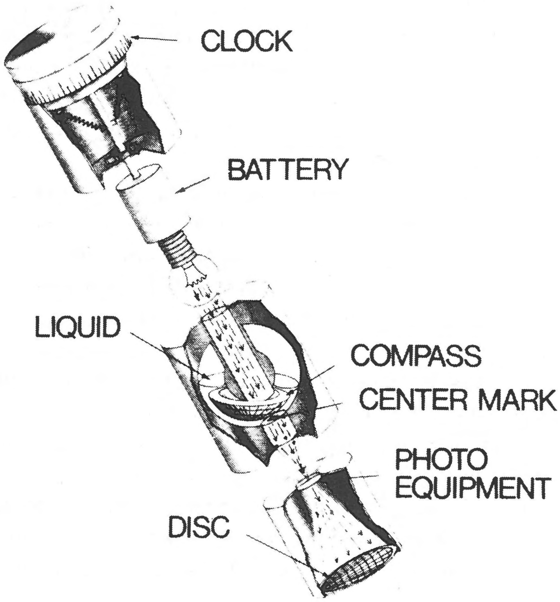

Fig. 9
Single-shot directional survey instrument (simplified, after Eastman catalogue).

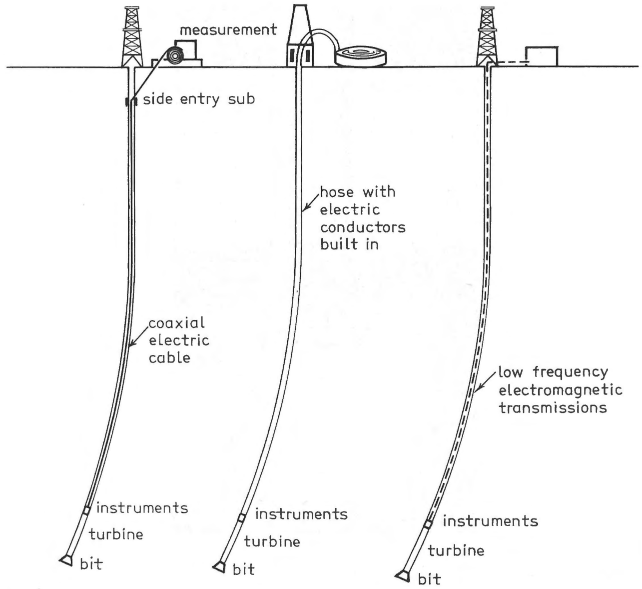

Fig. 11
Measurement while drilling.

(Fig. 7). After a certain time, set on the clock, a photograph is taken of the floating compass. The instrument is then pulled out and the photograph developed (Fig. 10). Both deviation from vertical and direction of the hole can be read from the photograph.

If a correction in deviation from vertical is required it may be necessary to change the assembly of drill collars and stabilizers. If a correction in the direction of the hole is required it is necessary to run the turbine with the bent sub again. Several surveys are necessary for orienting the deflection tools and during the drilling of the build up and the tangent section of the hole.

These surveys are time consuming. During running in, during the survey, and during pulling out of the instrument the drill-string must be held stationary which increases the risk of the string getting stuck. If the interval drilled between two surveys is enlarged the chance that the hole has turned in a wrong direction and that a time consuming correction is required is also greater.

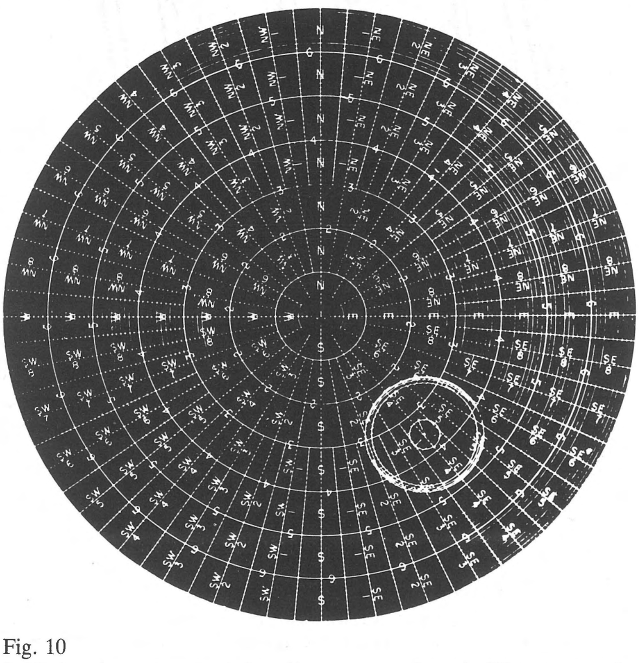

Fig. 10
0-70° floating compass (after Eastman catalogue). The concentric circles indicate the deviation from vertical. Example: deviation 35°; the direction of the hole is found on the radius SE 4.

To solve these problems attention is being given to methods of measuring deviation and direction while drilling is in progress. Several 'measurement while drilling' techniques have been developed, some are already in use while others are being tested (Fig. 11).

Signals from the instruments which are permanently located in the lower part of the drill-string can be transmitted to the surface by coaxial cables inside the drill-string or by electrical conductors built into a hose if the drill-string is replaced by a hose as is done in the flexodrill system. In other systems the signals are transmitted by creating shock waves in the mud (mud pulses). Experiments are carried out by using low frequency electromagnetic transmission or accoustic signals. When measurement-while-drilling is carried out in combination with a turbine and bent sub the assembly can actually be 'steered', for if continuous readings of direction are possible, immediate corrections can be made.

With the general improvement of directional drilling techniques it will become possible to drill holes with greater deviations from the vertical, thus increasing the area which can be reached by boreholes sunk from one offshore platform

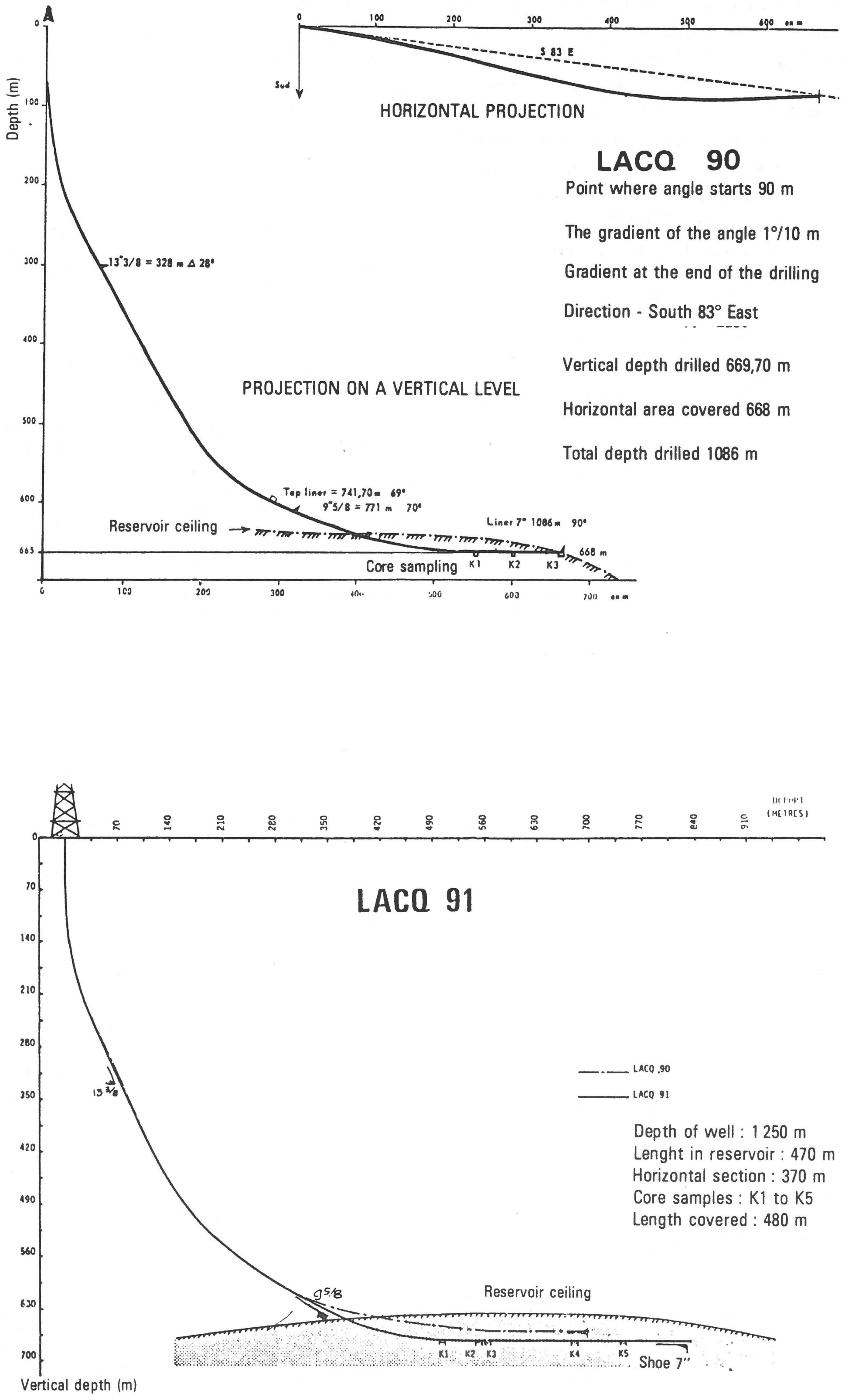

Fig. 12
Horizontal boreholes in Lacq Field, France (after Jourdain & Baron, 1981).

It is already possible to drill holes with a horizontal section of some significant length. Elf Aquitaine and the French Petroleum Institute (IFP) have recently drilled two successful horizontal wells in Lacq Field (Fig. 12). The near horizontal part of the second well was 1124 ft (370 m), five cores were cut, a logging programme carried out in open hole, and a 7 inch liner was run without difficulty. This experience shows that it must be possible to drill several holes into a horizontal coal layer from one surface location, to then follow the layer for a great distance. Gasification of the coal between the holes can then be carried out.

The position of the holes can be chosen so that the amount of coal to be gasified is much greater than that possible between two holes which penetrate the coal layer vertically.

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