

Drilling for Petroleum

DRILLING METHODS

When it has been established that a petroleum reservoir probably exists, the only way to verify this is to drill. Drilling for natural resources is not a new idea. As early as 1100 A.D., brine wells as deep as 3,500 ft were drilled in China, using methods similar to cable tool drilling.

Cable tool drilling. This was the method used by pioneer wildcatters in the nineteenth and early twentieth centuries and is still used today for some shallow wells. The method employs a heavy steel drill stem with a bit at the bottom, suspended from a cable. The tool is lifted and dropped repeatedly. The falling steel mass above the bit provides energy to break up the rock, pounding a hole through it. The hole is kept empty, except for some water at the bottom. After drilling a few feet, the drill stem (with its bit) is pulled out and the cuttings are removed with a bailer. The cable tool method is simple, but it is effective only for shallow wells. Progress is slow because of the inefficiency of the bit and the need to pull the tools frequently to bail out cuttings.

Rotary drilling. Rotary rigs are used for a variety of purposes — drilling oil, gas, water, geothermal and petroleum storage wells; mineral assay coring; and mining and construction projects. The most significant application, however, is oil and gas drilling. In the rotary method (introduced to oil and gas drilling in about 1900), the drill bit is suspended on the end of a tubular drillstring (drill stem) which is supported on a cable/pulley system held up by a derrick (see Figure 3). Drilling takes place when the drillstring and bit are rotated while the weight of the drill collars and bit bears down on the rock.

To keep the bit cool and lubricated, and to remove the rock cuttings from the hole, drilling fluid (mud) is pumped down the inside of the drillstring. When it reaches the bit, it passes through nozzles in the bit, impacts the bottom of the hole and then moves upward in the annulus (the space between the drillstring and the wellbore wall) with the cuttings suspended in it. At the surface, the mud is filtered

through screens and other devices that remove the cuttings, and is then pumped back into the hole. Drilling mud circulation brought efficiency to rotary drilling that was missing from cable tool drilling — the ability to remove cuttings from the hole without making a trip to the surface.

Equipment for rotary drilling is illustrated in Figure 3.

THE DRILLSTRING

Starting at the bottom, a basic drillstring for rotary drilling consists of the (1) bit, (2) drill collars and Bottom-Hole Assemblies (BHAs), and (3) drill pipe (see Figure 5).

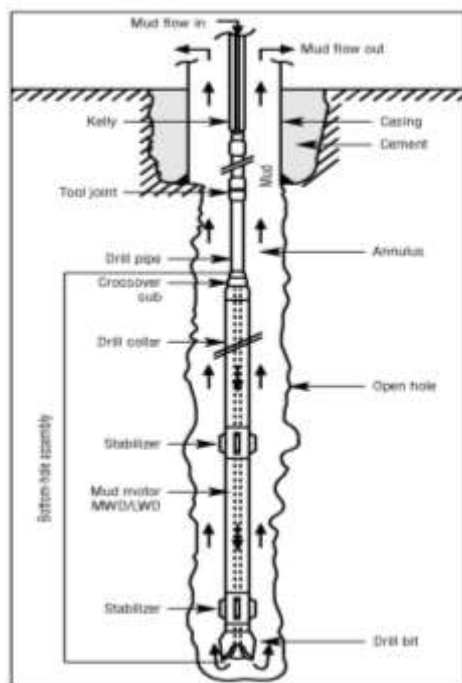


Figure 5: Drillstring components.

The BHA is located just above the bit and consists of drill collars combined with one or more bladed stabilizers (to keep the BHA and bit concentric), possibly a reamer (to keep the hole from becoming tapered as the bit diameter wears down) and other tools. MWD tools and mud motors are generally located low in the BHA, usually just above the bit. Sometimes, a set of “jars” is located near the top of the BHA. Jars can free stuck pipe by giving a hammering action when they are set-off by pulling hard.

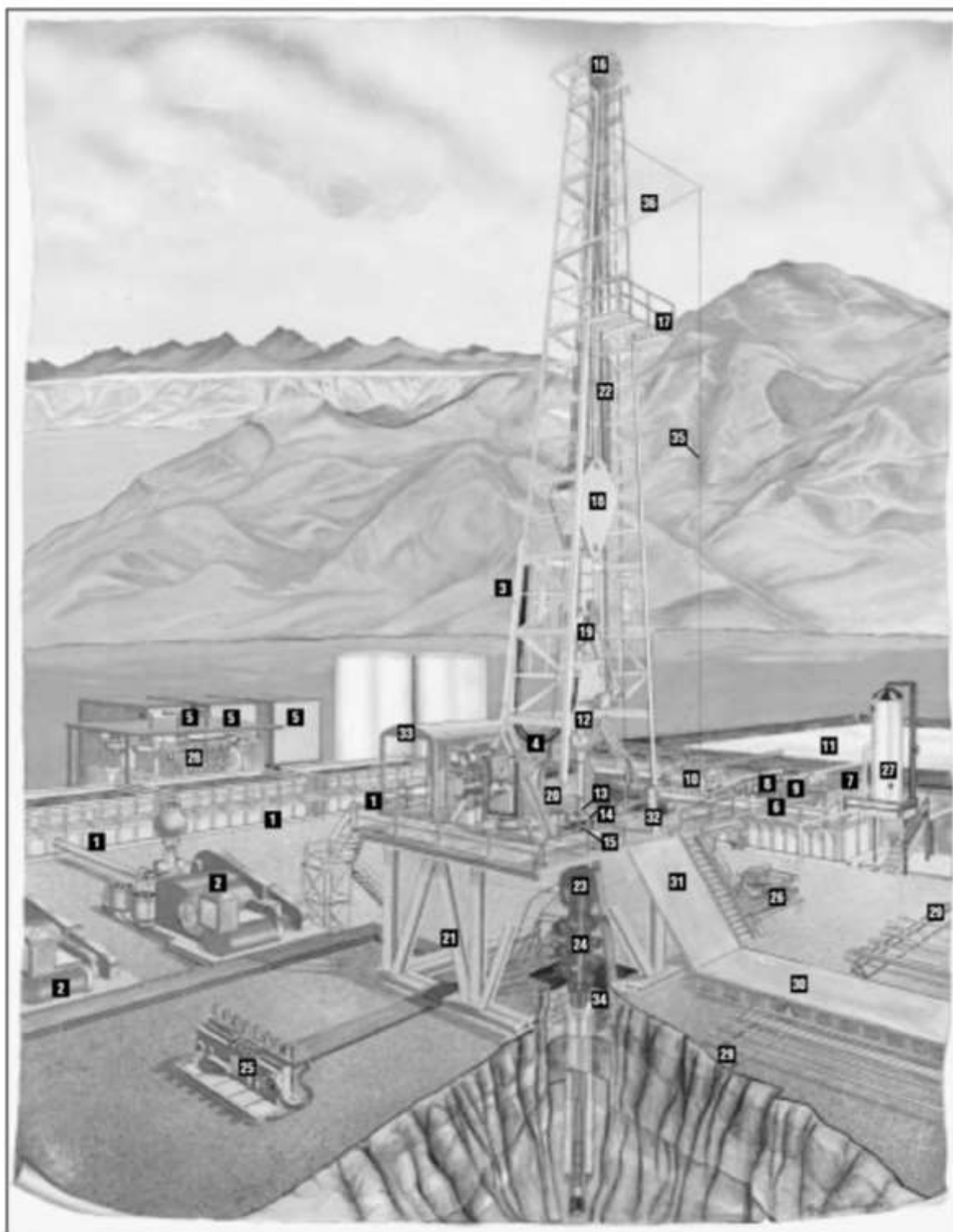


Figure 3: Diagrammatic view of rotary drilling rig (after Petex).

Circulating System

1. Mud pits
2. Mud pumps
3. Standpipe
4. Rotary hose
5. Bulk mud storage
6. Mud return line
7. Shale shaker
8. Desilter
9. Decander
10. Degasser
11. Reserve pits

Rotating Equipment

12. Swivel
 13. Kelly
 14. Kelly bushing
 15. Rotary table
- Hoisting System**
16. Crown block
 17. Monkeyboard
 18. Traveling block
 19. Hook
 20. Drawworks

21. Substructure

22. Drilling line

Well-Control Equipment

23. Annular blowout preventer
24. Ram blowout preventers
25. Accumulator unit
26. Choke manifold
27. Mud-gas separator

Power System

28. Generators

Pipe and Pipe-Handling Equipment

29. Pipe racks
30. Catwalk
31. V-door
32. Rathole

Miscellaneous

33. Doghouse
34. Cellar
35. Hoisting line
36. Gin pole

Drill collars are thick-walled, heavy joints of pipe used in the BHA to provide weight to the bit. Usually, one of the collars is made of non-magnetic metal so that a magnetic compass tool (survey tool) can be used to determine the inclination of the lower BHA and bit without interference from magnetic metals.

Each joint of drill pipe is approximately 30 ft long, and has a box (female connection) welded onto one end and a pin (male connection) welded to the other. These threaded couplings (tool joints) must be strong, reliable, rugged and safe to use. They must be easy to make up (connect) and break out (disconnect). Outer diameters for drill pipe range from 2 3/8 to 6 5/8 in.

The hollow drill string provides a means for continuous circulation and for pumping drilling mud under high pressure through the bit nozzles as a jet of fluid. The blast of mud knocks rock cuttings from under the bit, gives a new rock surface for the cutters to attack and starts the drill cuttings on their trip to the surface. This transmission of hydraulic horsepower from the mud pumps to the bit is a very important function of the mud.

Coiled-tubing drilling. This method employs a continuous string of coiled tubing and a specialized, coiled-tubing drilling rig. Rather than drilling with separate joints of the traditional, large-diameter, rigid drill pipe, the drillstring is smaller-diameter, flexible tubing. Unlike drill pipe which is screwed together to form the drillstring, and which must be disconnected into stands that are racked in the derrick during trips, the tubing comes rolled on a reel that unwinds as drilling progresses and is subsequently rewound onto its spool during trips. The coiled-tubing method greatly facilitates lowering and retrieving the drilling assembly.

Traditionally, coiled-tubing rigs have been used for workover and completion operations where mobility and compact size were important. With the development of downhole mud motors which do not require the use of a rotating drillstring to turn the bit, coiled-tubing units are now functioning as true drilling rigs.