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The Drilling Rig Part of Creating an Oil Well

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Topic: Supply/Production
Tags: crown block, drawworks, drill rig, kelly, traveling block, tubulars, weight on bit [list all tags]

Well, there are several ways to go after talking about the pressures that develop at the bottom of oilwells. But before going on to talk about completing the well, let me first just cover some basic terms and parts that go into getting the bit to actually turn and drill the well. In other words, today I want to talk about the oil derrick and what happens on the rig floor. Trying to update this, I discover that the term "derrick" has an interesting past.

> The term derrick comes from Thomas Derrick, a hangman who invented a type of gallows using a movable beam and pulley system during the Elizabethan era. During his lifetime, Derrick executed over 3,000 people, many of them with his modified gallows device, and the supporting framework for his gallows came to be known as a derrick.

Well, the ones that we are dealing with have to be a bit taller than that. The reason comes from the connection that we have to make from the rig floor down to the bit at the bottom of the hole. Because we are continually pushing the bit deeper into the ground we need to use something that we can keep extending. (From this it also follows that the top guy on the rig got to be known as the **tool pusher**).

At the same time, this connecting device has to be able to allow the mud to get down to the jet nozzles on the bit. The logical way of doing this is to have a tube or pipe, into which the drilling bit can be threaded on the lower end. (Which gives rise to the expression **oilfield tubulars**). Now, by attaching the mud pumps to the upper end of the pipe, we can also get the mud down into the bit. There is usually a special piece of pipe that fits between the bit itself and the main sections of the pipe, and this is called the **drill collar**. These normally have a thicker wall than normal pipe so that they can add more weight to push the bit into the rock. (see below).

Drill pipe comes in various sizes, depending on the hole that is being drilled, but for the sake of an example we might use a pipe that is 5.5 inches diameter on the outside and 3.25 inches wide on the inside. This would weigh around 14 lb a foot, and is normally used in 30 ft lengths. This length is a standard, and the pipe will have a threaded connection welded to each end, known as the **tool joint**. One is male and one is female, so that additional lengths of pipe may be threaded into the original piece to extend the overall length as the hole gets deeper.

Normal male pipe ends (taped over to protect the threads)

To handle these lengths of pipe, and to have them already in place and vertical before we need them, we need a handling system that can lift the pipes into place, and this tall initial support structure is called the **mast**. Typical modern masts may be around 140 ft tall, with the space between the legs around 12 ft. So to follow through the parts I'll make a simple version of a mast, and then as I explain what the parts are, I can add them to the model.

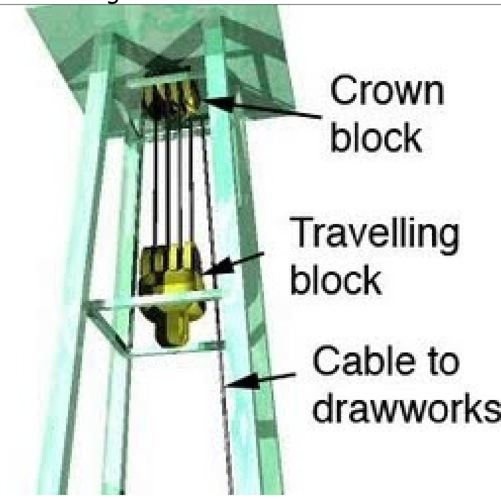
Basic Mast

I mention the length because there are several things that control the **rate of penetration (ROP)** of the bit, and one is the thrust that is applied to push the bit into the rock. This comes from the weight of the pipe that is connected to the bit, and thus is known as the **weight on bit**. However, if you do the arithmetic, 14 x 30 = 420 lb. per length of drill pipe. So if we have one length of pipe, we are pushing the bit into the ground with 420 lbs of weight. Add another length and we are up to 840 lb. And so it continues, except that there is, for each bit and rock, a bit weight that will cause that bit to drill at its best ROP. Typically this might be around 15 - 20,000 lb depending on hole size and rock type. But we get that weight from the pipe with only 36 lengths, or a total of around 1,000 ft of drill pipe. But increasingly we might be drilling a well that is much more than 7,000 ft deep. (It is actually a bit shorter, since for the first few hundred feet the additional weight of the drill collars is needed to keep the thrust up).

To keep the bit weight at the best level to give the fastest ROP, the driller will carry the rest of the weight of the pipe through the derrick and will adjust the weight on bit by controlling the amount of lift through a block and tackle arrangement to a **traveling block** on the top of the drill pipe. So to the model we will add a platform at the top, (or **crown**) of the derrick which will have a pulley on it to feed cable down to the travelling block.

Crown block at top of mast (OSHA)

The cable that connects the traveling block to this second crown block at the top makes a number of loops between the two blocks and in this way the cable can carry up to a million pounds or more of weight.

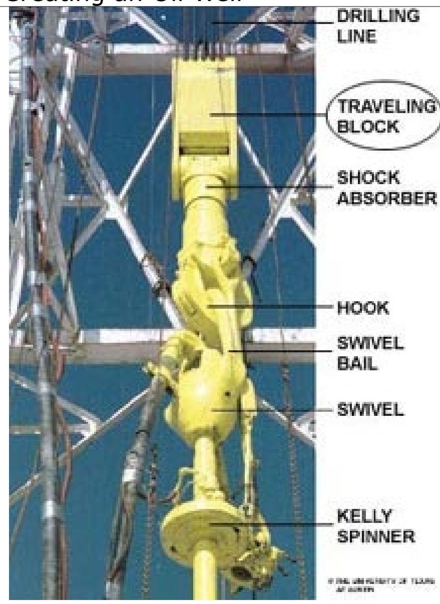


Schematic of the two blocks at the top of the mast

From the crown block the cable feeds back down to the reel on the rig floor where it is stored. The reel and the motors that drive it are known as the **drawworks**, and the driller controls the reel rotation and thus the weight carried through the cable to the derrick, to control the amount of thrust on the bit.

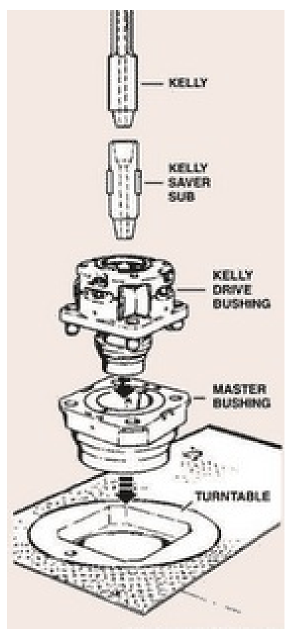
The hoist and motor of the Drawworks (Schlumberger)

There are two other things, however, that have to be controlled. Firstly the bit has to turn, and so there must be a way of allowing the pipe to rotate. This is done by adding a swivel below the traveling block. The swivel also allows a connection to the mud system and mud can be pumped into the pipe, without the mud line having to turn.



Travelling block showing the swivel and mud line connection (OSHA)

This is done through a **rotary table** that sits on the **rig floor** and a special piece of pipe (some 43 ft long), known as **the Kelly**, that is connected between the swivel which sits right under the traveling block, and the first length of drill pipe. The pipe is square or hexagonal and will slide through the turntable as the hole gets deeper. At the same time the shape allows the turntable to grip it and turn it, and the attached drill string that connects below it to the drilling bit at the bottom of the hole. There is a motor, generally under the rig, that drives the turntable.



Drive through the turntable and Kelly drive to the Kelly, and the underlying drill pipe (OSHA)

Some more modern rigs can have an electric motor at the top of the mast, attached to the bottom of the traveling block, which drives the pipe without the need for the Kelly and rotary table.

Top drive that can be used in small mast applications (Tesco)

Bear in mind that after the drill bit has penetrated 30 ft (the length of a single length or **joint** of drill pipe) then drilling must stop. The Kelly is disconnected from the top joint, and raised while a new joint is swung in up the **catwalk** (from where spare joints are stored on the rig) and connected, at the bottom end to the existing string, and at the top end to the Kelly.

The drill is then ready to go forward again. While I am not up on current performance, I was once taught that a good crew cannot make more than 7 connections, or drill more than 200 ft of hole an hour. (There is another way of adding pipe that can allow a faster ROP but we'll get to that another time). Now also remember that if the bit needs to be changed because it wore out, or because it can't drill in the rock that it has not started to go through, then the entire string above the bit has to be removed, one joint at a time, until the bit reaches the surface. Then it is replaced, and the joint in turn have to be replaced, again one-at-a-time, until the bit hits bottom again. Now hauling the string out of the hole goes a little faster than drilling, but you can see that this process, known as **tripping**, can take more than a day. Which can be quite expensive, especially since, while you are tripping you are not making hole, and that is what the rig is being rented to do.

When tripping the well, the drill pipe has to be held in place with **slips**, which are a wedge shaped tool that fits around the top of the pipe and grips it, while the connections are made or unmade.

Slips prepared to slip around the drill pipe (Schlumberger)

Well, this is a bit of a hard subject to cover in less than 50 minutes, and without 60 pictures, so if there are things that are not clear, or if some of my numbers aren't quite up to date please comment or ask.