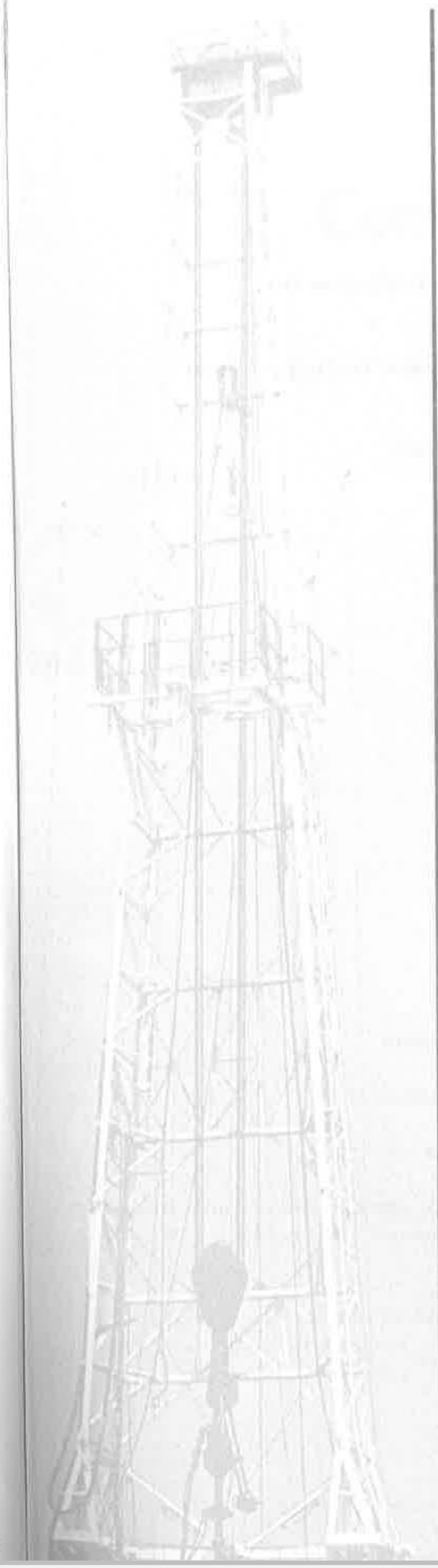

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FOURTH EDITION

by Kate Van Dyke

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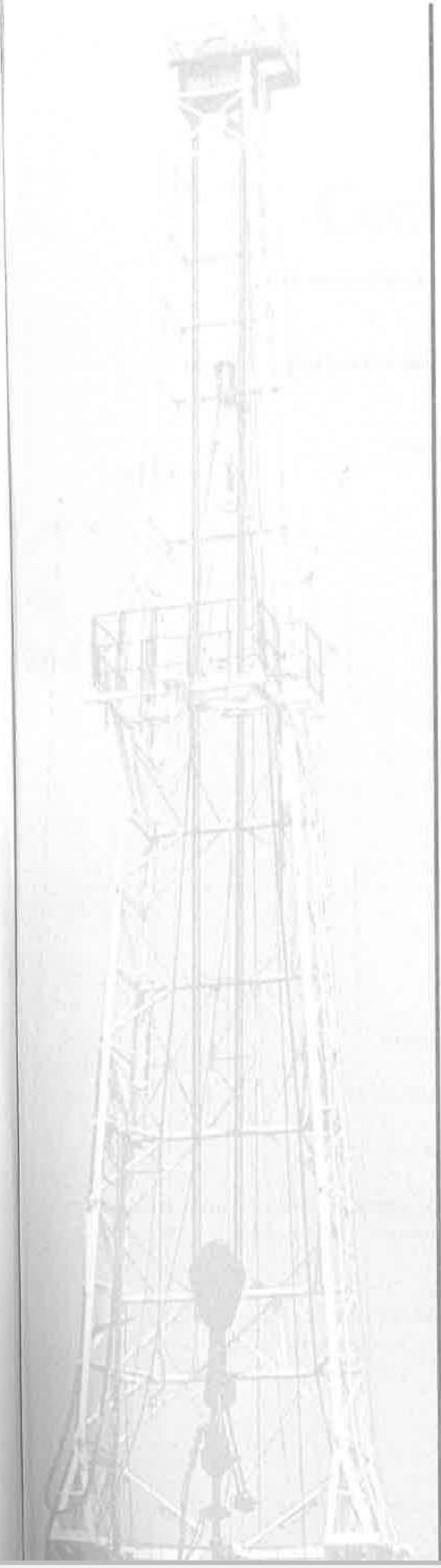

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RESERVOIR PRESSURE

All reservoir fluids are under pressure. The weight of the fluid itself creates a normal pressure. Abnormal pressure occurs when the weight of the formations on top of the reservoir is added to the fluid pressure.

Normal Pressure

Fluid pressure exists in a reservoir for the same reason that pressure exists at the bottom of the ocean. Imagine a swimmer in a large swimming pool who decides to see whether he or she can touch bottom. Everything is going well except that the swimmer's ears begin to hurt. The deeper the dive, the more the ears hurt. The reason for the pain is that the pressure of the water is pressing against the eardrums. The deeper the swimmer goes, the greater the pressure.

Just as water creates pressure in a swimming pool, fluids in a reservoir create pressure. When the reservoir has a connection to the surface (fig. 1.38), usually the only pressure in it is the pressure caused by fluid in and above it. As long as this connection to the surface exists, rocks that overlie a reservoir do not create any extra pressure in the reservoir. Even though their weight bears down on the formation, fluids can rise to the surface and escape. Imagine again the swimming pool full of water. Dump a huge load of rocks into it. The rocks do not increase the water pressure; instead the water sloshes over the sides.

The same thing happens in a reservoir. Unlike a swimming pool, however, a reservoir's connection to the surface is usually circuitous. It may outcrop at the surface many miles away, or it may be connected to the surface through other porous beds that overlie it. In most cases, though, as long as the reservoir has some outlet to the surface, the pressure in it is caused only by the fluids and is considered to be normal pressure.

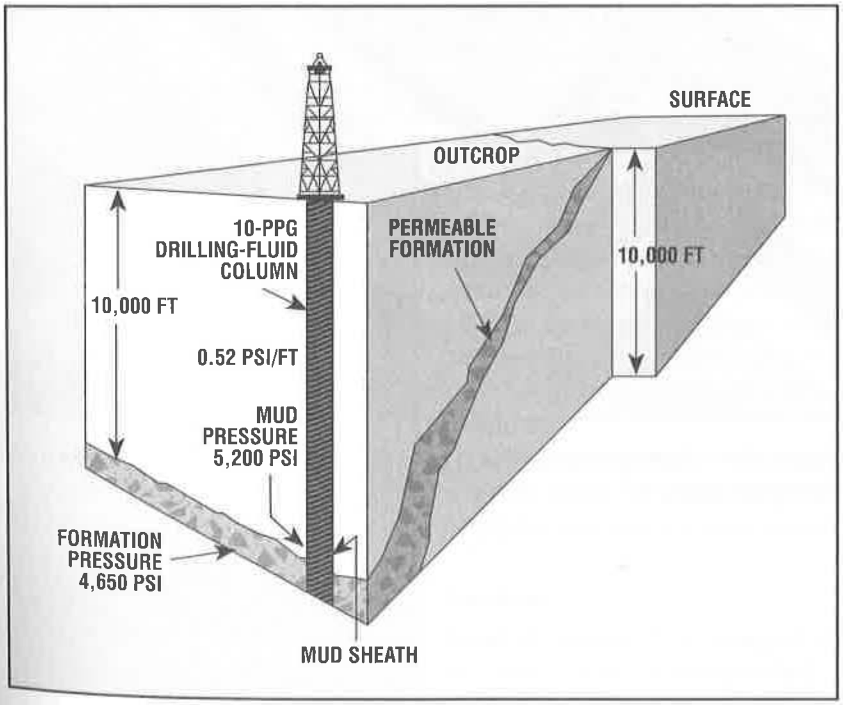

Figure 1.38 When the petroleum reservoir has a connection to the surface, the pressure is considered normal.

Once the kelly is made up tightly to the joint, the driller picks them up and moves them from the mousehole to the rotary table. The crew stabs the bottom of the new joint of pipe into the top of the joint of pipe coming out of the borehole and again uses the kelly spinner to make up the joints. With the new joint made up, they pull the slips, and the driller lowers the pipe until the bit nears the bottom. Then he or she starts the pumps, begins rotation, applies weight to the bit, and drills another 40 feet (12 metres) or so of hole, depending on the length of the kelly. The crew repeats this process each time the kelly is drilled down.

When the rig uses a top drive, the crew follows essentially the same procedures to make up the drill string, often making up two, three, or four joints at a time instead of one. The multiple made-up joints, called a *stand*, sit in a rack on the rig floor to the side of the mast or derrick.

Eventually, at a depth that could range from hundreds of feet (metres) to a few thousand feet (metres), drilling comes to a temporary halt, and the crew pulls the drill stem from the hole. This first part of the hole is known as the *surface hole*. Even though the formation that contains the hydrocarbons may lie many thousands of feet (metres) below this point, the toolpusher stops drilling temporarily to take steps to protect and seal off the formations close to the surface. For example, drilling mud could contaminate zones containing fresh water that nearby towns use for drinking. To protect such zones, the crew runs special pipe called *casing* into the hole and cements it in place.

Tripping Out

The first step in running casing is to pull the drill stem and the bit out of the hole. Pulling the drill stem and the bit out of the hole in order to run casing, change bits, or perform some other operation in the borehole is called *tripping out*.

To trip out, the driller stops rotation and circulation. Then, using controls on the drawworks, he or she raises the drill stem off the bottom of the hole until the top joint of drill pipe clears the rotary table and holds it there. Then, the rotary helpers set the slips around the drill pipe to suspend it in the hole. Next, using the tongs, the rotary helpers break the kelly out of the drill string and put it into the rathole (fig. 4.45). Since they leave the kelly bushing, the swivel, and the rotary hose on the kelly when placing it in the rathole, the area above the rotary where the top of the drill string protrudes from the hole is clear. Only the traveling block hangs above the drill pipe suspended in the hole.

Attached to the traveling block are a set of drill pipe lifting devices called *elevators*. The elevators usually remain attached to the traveling block at all times and swing downward into position when the crew removes the swivel from the hook. Elevators are clamps that can latch onto the tool joints of the drill pipe (fig. 4.46). The crew latches the elevators around the drill pipe, and the driller raises the traveling block to pull the pipe upward. When the third joint of pipe clears the rotary table, the rotary helpers set the slips and use the tongs to break out the pipe. The pipe is usually removed from the hole in stands of three joints. The crew guides the stand to the rack on the rig floor.

Once the bottom of the stand of pipe is set down on the rig floor, the derrickhand goes into action. Standing on a small platform called the *monkeyboard* that is about 90 feet (metres) high in the mast or derrick,

WELL STIMULATION

The term *well stimulation* encompasses several techniques used to enlarge old channels or to create new ones in the producing formation. Since oil usually exists in the pores of sandstone or the cracks of limestone formations, enlarging or creating new channels causes the oil or gas to move more readily to a well. Sometimes the problem is low permeability. In this case, the well will be stimulated immediately after completion. In other cases, the natural permeability of the rock may be adequate, but the formation near the wellbore may be damaged in a way that restricts the flow channels in porous rock. Formation damage can occur during drilling, completion, workover, production, or injection.

There are three ways to do this. The first and oldest method is to use *explosive fracturing*. During the 1930s, *acid stimulation*, or *acidizing*, became commercially available. *Hydraulic fracturing*, the third stimulation method, was introduced in 1948.

Explosives

As early as the 1860s, crews exploded nitroglycerin inside wells to improve their productivity. They simply lowered a nitro charge into the open hole on a conductor line and detonated it to fracture the formation. *Nitro shooting* became fairly routine until the advent of acidizing and hydraulic fracturing. For a time in the 1960s, lease operators experimented with nuclear explosives in a limited number of gas wells. While this method increased production somewhat, the cost was prohibitive.

Oil companies are still interested in explosive techniques because certain kinds of tight formations do not respond readily to either acidizing or hydraulic fracturing. Research continues today to find other techniques that might increase production, but currently fracturing and acidizing are the most effective well stimulation methods.

Hydraulic Fracturing

Hydraulic fracturing is all about pressure. Several powerful pumps (fig. 5.26) inject a liquid, the *fracturing fluid*, into the well at a fast rate. The fluid develops a high pressure that actually splits, or fractures, the rock. To visualize this, imagine splitting a log with an axe. The axe head is a wedge.

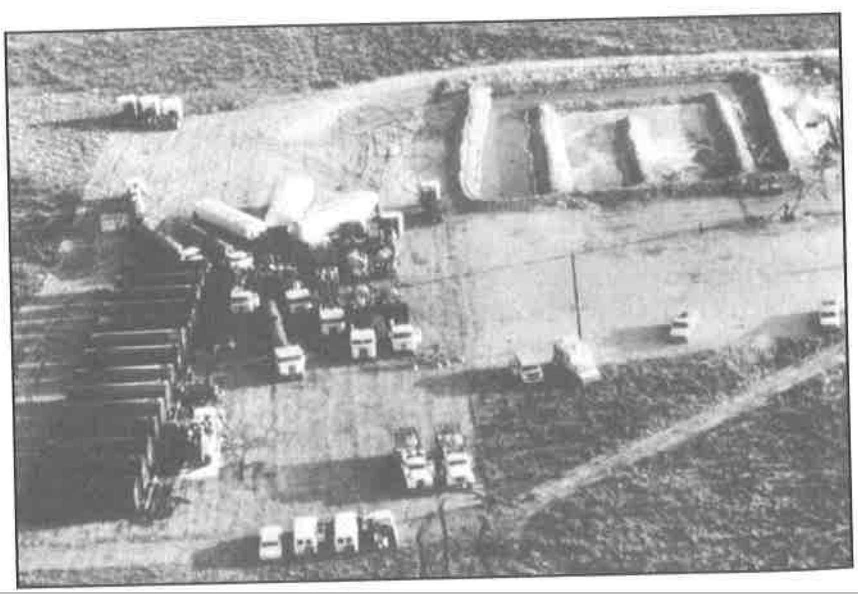

Figure 5.26 Several powerful, truck-mounted pumps are arranged at the well site for a fracturing job.

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