generally require perforated plate design. In bubble caps, thick mashes can gather around the caps and partially plug the flow. Perforated plate distilleries—in which the vapor jets up through the plate through small holes, while the mash solids and surplus liquid go over the **weir** dam or down the downcomer—work better with thick mashes in continuous distillation.

There are several advantages in using a perforated plate still even for **batch distillation**: Less energy is used when steam is the source of heat, and a smaller-diameter distilling column containing the perforated plates will still produce more alcohol than a larger-diameter bubble cap continuous distillery.

But perforated plate stills are expensive, and somewhat difficult to design and build. The best compromise for the batch producer is the packed column type, since it saves space and energy, and is the least expensive and easiest to construct.

The Packed Column Still

Packed column stills are an offshoot of oil industry technology for distilling or cracking oil into its component parts for use in different industries and materials. While the oil industry distills several chemicals at once, we're only concerned with alcohol and water.

The packed column still uses the same enrichment and countercurrent flow principles that other stills do. But instead of having separate plates with distinct and separate proofs and boiling points, the packed column allows a gradual, continuous rise in proof and lowering of boiling point, as you go higher.

Plates are replaced inside the column with a packing material to give the alcohol/water vapor sites on which to condense

Fig. 9-15 Bronze wool packing. *Far superior to marbles, bronze wool is okay to use in three-inch-diameter columns. In six-inch columns, the wool uses a lot more energy than pall rings to overcome greater back pressure, and the lower pads tend to load up with particles of mash in a pretty short time.*

Fig. 9-16 Pall ring packing. *Pall rings come in a variety of materials, but the plastic ones are the least expensive and work well in alcohol/water distillation.*

Fig. 9-17 Lathe chip packing. *Stainless steel lathe chips are an economical packing if pall rings are too expensive initially. As far as energy economy goes, they rank between pall rings and bronze wool.*

and revaporize. Remember, each time alcohol and water boil, the alcohol rises, leaving a little more water behind. Now, instead of that overflow running down a tube to a hotter plate to have its alcohol stripped, a droplet of condensed vapor falls a short distance through the porous packing in the column until it reaches a sufficiently hot zone for the alcohol to revaporize. It's a dynamic process—the vapor is condensed and revaporized literally thousands of times on the way to the top of the column. Each revaporization leaves a small water deposit, which ultimately makes its way to the bottom of the column and back into the mash pot.

Alcohol/water vapor requires a lot of space to rise through, but the vapor needs to encounter a lot of surfaces on which to condense on the way up. So your packing material should provide plenty of surface area and still leave a great deal of free gas space. While rocks, marbles, or pieces of glass packed into the column may provide a lot of surface area, they don't allow enough free gas space to be a good packing material. Too little free gas space causes a loading-up effect in the column, in which there's so much condensed wash in the passages that the vapor has a hard time getting through. To compensate, you'd need higher pressure, a taller column, and more energy to run the still.

I can recommend several excellent materials for packing. Bronze or stainless steel **scrubbing pads** or **lathe chips** made of stainless steel or any other nonferrous metal fit the still requirements. Even better are **pall rings**, which were computer-designed for distillation columns. They provide an enormous amount of surface area and occupy only about 5% of the volume of the still column. Since pall rings vaguely resemble shotgun wads, some people have tried (not too successfully) to use such wads for packing.

Even though pall rings are more expensive than some materials, the 20+% energy saved justifies

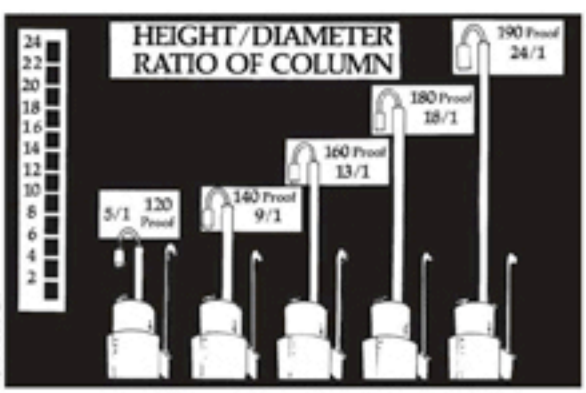

Fig. 9-18 Height-to-diameter ratio for packed columns. *These ratios are based on pall ring packing and 192-proof distillation. Building columns taller will not raise the proof of the alcohol and will use more energy.*

their use, so invest now to save later. Enough 5/8-inch diameter pall rings to fit a six-inch diameter column still (approximately 2-3/4 cubic feet loosely packed) costs about $130. Lathe chips cost about $10 to $15. Scrubbing pads are about $100 purchased in bulk. Many of my students started off with one of the cheaper packings, then switched to pall rings once they'd sold some fuel and made some extra money.

Another commercial packing material to consider is **ceramic saddles**. Although they are cheaper than pall rings and almost as efficient, they seem to break down over time, whereas pall rings are nearly indestructible. While newer saddles are being made from plastic, the cost still isn't sufficiently cheaper than pall rings.

Lathe chips are a byproduct of the metal machining industry. When a cylinder of metal (or some plastics) is turned rapidly on a lathe for cutting or reshaping, the material removed comes off in spiral chips. These chips (the coarser the better) are relatively efficient packing material in stills eight inches in diameter or less. Of course, your chips should be of a material that won't rust. Don't worry about any cutting oil that may remain on lathe chips—it'll drop to the bottom during the distillation process the first couple of times you use the still.

Since alcohol can reach 190+ proof in a packed column, after condensing and revaporizing many times on the way to the top, it follows that there is a definite relationship between the height of the column and the proof of the alcohol. The farther it has to travel up the column, the more times it condenses and revaporizes.

There is, of course, a point past which your alcohol can't get any purer, no matter how many more revaporizations occur. This point is approximately 192 proof. The distance your alcohol vapor must rise to get to this point is expressed as a ratio of 24 units of height to one unit of diameter. Any higher wastes energy. Any lower and you get a lower-proof yield, because your vapors don't get to condense and revaporize enough times to reach the 190+ proof level—they'd still be carrying too much water. A height-to-diameter ratio of 16 to 1 yields 160 proof at best.

Your choice of height to diameter should be determined by how you plan to use the alcohol. A fuel oil burner converted to alcohol requires a minimum of 150 proof. If you're going to generate electricity with alcohol, you may find 170 proof more than adequate to run your generator. Most people, though, are planning to use this alcohol to fuel their cars, or at least want the option to do so. Although you can run a car on as low proof as 170, it's preferable to use a higher proof (see Chapter 14). A column capable of producing 190 proof can be "detuned" easily to produce a lower proof.

In a batch still, the diameter of the column determines the output in gallons per hour, but the relationship between diameter and output isn't as straightforward as the height-to-diameter ratio. A column still six inches in diameter yields about eight gallons per hour of 192-proof alcohol, an eight-inch still yields 16, and a 12-inch gives you about 35.

Matching Tank Size to Column Size

COLUMN SIZE	OUTPUT (GAL/HOUR)	RECOMMENDED TANK SIZE (GAL)
2"	¼ to ¾	10–50
3"	½ to 1-½	30–150
4"	1–3	50–250
6"	5–10	200–1000
8"	8–20	500–1500

LEFT: Fig. 9-19 Matching tank size to column size. *Too small and the run time is short and hard to control. Too large and you run into logistical issues, planning on supervising the still for too many hours out of a day.*

Packed column stills are clearly the most cost-effective up to 12-inch diameters. Once you get above 35 gallons per hour, it begins to make sense to consider going to a continuous distillation design for ease of automation and energy savings. Going much smaller than a six-inch still is hardly worth it: A three-inch still, for example, produces only about a gallon per hour.

Packed column stills require a lightweight support plate of expanded stainless steel into which the plastic pall ring packing is poured. Packed column stills need minimal maintenance. After a year of heavy use, the packing will accumulate a coating of proteins and other guck. You can clean the packing by removing it from the column and washing it, or by pouring a biological solvent down through the top of the column, to dissolve the protein off the packing. If you use the solvent method, do it every four months or so, and still fully disassemble the column and wash the packing every couple of years.

Recirculate the cleaning solvent several times by pumping it through the column from top to bottom and back through a filter.

When you build your still, it's important to scale the tank to your column correctly. Putting a huge column on a tiny tank is obviously not practical, nor is a tiny column on a large tank. What is practical is distilling alcohol at a rate that allows you to complete a run in a normal working day or shift, somewhere between five to ten hours. It will take about six and a half hours to distill alcohol from the contents of a 500-gallon tank through a six-inch column; 500 gallons of mash yield 50 gallons of alcohol.

Column Control Factors in the Packed Column Still

Two factors are under your control in a packed column: temperature gradation and the pressure of the vapor entering. And both these phenomena are related. The more pressure there is, the more vapor enters the column, and the more temperature control is required. If your pressure is too high, you'll continually be fighting to keep the column temperature in line.

First, let's look at temperature. To ensure that the top of the packing contains high-proof alcohol on its way to the condenser, the temperature should be close to 173°F. If we keep this point at a controlled 173°F, only relatively pure alcohol can pass it. At the start of the run, the column won't need controlling; the vapors will be high enough in alcohol content to distill automatically at very high proof.

But as alcohol is depleted from the main batch, the temperature of those vapors rises (due to the higher water content) and begins to heat up the column. When this happens, you'll want to begin condensing vapor above the packing to 173+°F.

On the small scale, the usual method for cooling is by flowing water through cooling coils placed

SHOULD WE GET USED TO GLOBAL WARMING?

Reporting on the White House admission that global warming was due to mankind—by extension MegaOilron—Terry Moran of ABC said, "Today's report paints the starkest pictures yet when scientists say what could be the impacts in the U.S. of global warming, from the diminishing snowpacks in Western mountain ranges, which could cause real water problems in California and elsewhere, to the disappearance of barrier islands on the Atlantic Seaboard." When asked by Peter Jennings what the Bush administration thinks mankind should do, Moran answered, "Get used to it."[2]