Building a still at low cost

Practical guide for building gadgets + few new ideas.

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Introduction

This document is based on my notes taken during the last few years while I've been studying the art of distillation. In this document I'll give instructions for building an efficient low cost still that'll give you pure ethanol at 95.6% ABV strength. I'll go through several ways of doing it, from manually operated to automated system (ARC). I'll also give instructions of building a pot still and how to use it to make decent whiskey. My research on heads removal techniques is still incomplete and I may have to write another chapter about that when I've found a system that I'm completely happy with. I'll give few approaches for that anyway.

I decided to make this document available for everybody to make it easier for beginners to start this hobby, and also to encourage long time distiller to try and develop new techniques. It is to be noted that home distillation is sadly illegal in most countries; therefore all the experiments mentioned in this book have been carried out in a country where distillation is legal. I hope this document will in it's small part help in making home distillation acceptable in people's minds and eventually lead to legalized home distillation in all civilized countries.

I recommend you read through this document and think it all a little bit before you start building your system. It's also a good idea to ask for some advice before spending money on something you may not need. A good place to ask about and discuss these things is yahoo's discussion group at http://groups.yahoo.com/group/Distillers/

I hope you enjoy reading this document and have fun building and operating your systems.

For questions you can contact me via e-mail.

Greetz, Riku – abbababbaccc@yahoo.com

A still

A still is a device or apparatus which boils an alcohol liquid solution (mash) inside a boiler to form vapor, possibly uses a column for further purification of vapors produced and condenses said vapors to liquid again. This process increases the alcohol content of the liquid that's coming out of the system. I won't go into science behind the phenomena, there are many good books handling the subject and I'm more of a practical type of person. Let's just say that it works and people have built stills for centuries and enjoyed the product produced that way. So to cut it short to make a still we need a boiler, possibly column and a condenser or several of those. Next chapters will explain how to make those things, what types of constructions exist and how they are operated. We'll start with a cheap boiler, as it is needed in almost all stills (continuous still can be built without an actual boiler).

How to make a cheap boiler

One of the first tasks of a still builder is to find a suitable boiler for the still. I myself faced this problem and went the usual 25l stockpot + hotplate route. Total cost was in the neighborhood of 150 euros, and while they have served me well I just wish someone had told me about easier alternatives at that time. Later I made a simple pot/column still from a fermentation bucket with a total cost of ~30 euros (not including still heads). I thought such a cheap and easy to make solution would be of interest to many, so here's a description how to do it.

Note, most Polypropylene plastics will leach softeners when in contact with high% hot alcohols. It is recommended that this boiler is not used with very high % alcohol in the boiler (i.e. no triple distillation for pot stills). The hot high% ethanol in practice exists only inside the column, so there's no direct contact between boiler and high% ethanol unless the mash is high%.

Parts needed:

1 30-32 liters fermentation bucket made of Polypropylene (arrow triangle with PP or number 5 in it)

1 heating element from electric kettle, cordless ones can be plugged straight to a computer power cable. I used one rated at 2200W, but unless power controller is used you should select a size that fits your intended use as described later

1 42 mm capillary joint (or whatever size fits best your planned still head(s), see chapter columns for more information), additionally piece of copper sheet and few wood screws for the collar.

1 piece of plywood or similar material, ~30cm x 30cm x 1 cm dimensions or what ever fits on topside of the fermentation bucket lid.

1 tube of aquarium grade RTV silicone

~10 pieces of SS wood screws

Tools:

Common hand tools will do, a drill, semi circular file, knife or a hacksaw, screwdriver and soldering equipment if you do the collar

Start by removing the heater element from the kettle. Typically there are screws attaching the metal part of the element (inside the kettle) to the plastic part on the outside with a gasket in the wall of the kettle. Tie the thermostat of the element to the open position. Note the shape and size of the opening for the element. Now you have two choices to attach the element to the fermentation bucket, bottom or the side. It's easy to find a straight area at the bottom to make a hole and attach the element to. The downside is that you need to make a rack for the boiler so there's enough room for electric connections at the bottom of the boiler. Making the hole to the side has a disadvantage of non-straight surface that makes leaks more likely. Whichever way you choose, transfer the gasket

from the kettle and use lots of silicone to seal the element properly. Personally I installed the element(s) at the bottom and made a rack from few pieces of two by fours.

PIC – boiler and heating element

Now we need to modify the lid to accept the column or pot still head.

If you only need a pot still you can take a shortcut here. Fermentation buckets typically have a rubber gasket with 10mm opening for the airlock. You can make a simple liebig or worm type condenser from 10mm copper pipe and just stick it to the lock gasket and be done with it. Be prepared to replace the gasket after every 5 or so runs (cost is ~1 euro for a gasket).

Note: 10mm pipe will not tolerate full 2kW power; use a smaller element (1 kW or less) or power controller.

To attach the column or other still heads to the boiler I'm using a capillary joint and Teflon tape for sealing. Capillary joints are used for connecting one pipe to another and can be bought for few

euros for most pipe sizes at your local plumbing store. They are usually soldered and they fit quite tightly around the pipe end. This tight fitting causes the soldering tin to be sucked to the joint via capillary forces. The tight fit also works great when you want to make a column that can be disassembled easily. Just wrap a few rounds of Teflon (PTFE) tape (used for sealing pipe threads in plumbing applications) around the pipe end before you insert it to the joint + few rounds around the seam and you have pretty much leak free joint for a distillation. If you need to run your still for very long periods at the time (i.e. several days) you might add a rubber clamp around the seam as well but generally this is not needed. Teflon tape absorbs ethanol and gets “wet” over time, but it also prevents the vapors and liquid from escaping.

Now the joint needs to be attached to the fermentation bucket lid. The lid is quite flexible, especially when it gets hot, so we need to strengthen it a bit. For that purpose I used a piece of plywood, other relatively inflexible and easy to work with materials will do as well. First you should make a disk out of the plywood that covers nicely the flat part of the lid. Hacksaw is nice for the job, but you can use whatever tools you have available.

Note: if you spill hot ethanol on absorbent materials like plywood the glue that holds it together may loose it properties and cause disintegration of the disk. Don’t ask me how I know it …

After you have made the disk it is time to attach that joint to the disk. I started by making a bit too small hole to the disk. After that I filed it to become a very tight fit, and inserted the joint by hammering it through the hole (use a piece of wood in between the joint and hammer). This provided rigid enough support that’s already pretty well sealed. If you can’t make the hole tight enough you can solder a small collar to the joint that prevents it from falling through the hole, drill few holes to the collar and attach it to the plywood disk with screws. Over the time my joint came loose after ~20 uses, so I eventually did the collar thing as well.

After that it’s time to make a similar hole to the lid. You can leave it 1-0.5mm too small as the lid will flex a bit and it will make the joint seal better. When that’s done it is time to attach the disk and joint to the lid. For that I used RTV type aquarium grade silicone as a glue and sealer. I roughened the top surface of the lid a bit with sandpaper to make the silicone grip better. I used lots of silicone, especially around the holes where joint goes through. Push the disk to the lid, add another bead of silicone at the lower surface of the lid at the joint/lid seam, use the SS screws to secure the lid to the disk (I did that from boiler side of the lid) and you are done. If you want to play it safe you can use washers + silicone between the lid and crew heads, or even make a plate from SS or similar material

for the boiler side of the lid. That way you'll "clamp" the plastic lid between disks and have a very sturdy lid for your boiler. Let it cure for at least 24 hours. The silicone and PP fermentation bucket won't attach very well, so using contact type glue to attach the disk to the lid is also worth considering.

PIC- The finalized boiler

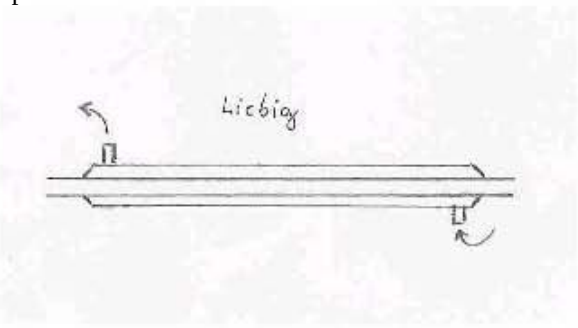
Pot still heads/condensers

If it's pure ethanol you are after do not bother with pot stills, they are best used for flavored drinks like whiskey, rum, brandies etc.

Water-cooled:

For pot still there's a variety of different designs to choose from. Traditional choices are a Liebig type condenser or a worm in a bucket type condenser.

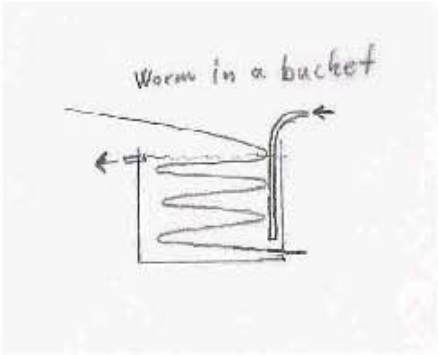
A Liebig is basically a straight pipe that has a cooling jacket. For our purpose you can make one from 10mm pipe that has 15 or 18mm pipe as a cooling jacket around it, or you can use a PVC hose, T-hose fittings and some glue/silicone to make the jacket (fitting at both ends, glued/siliconed to pipe (see that water gets to the hose but doesn't leak out), hose in between the fittings). Copper to copper joints are best made with solder (tin/led solder works fine when there's no contact to end product), plastic to copper joints can be made with epoxy type glues or even silicone. Note that epoxies will soften over time if in contact with hot ethanol.



Pic - Liebig

Another alternative is to wind a brake line type small copper pipe (~5mm or even larger) around the straight pipe in place of the jacket of Liebig condenser and use some solder to attach it and to improve the heat transfer.

Worm in a barrel means a copper pipe wound to a spiral and inserted to a bucket filled with water. A very simple version can be made from ~5 meters of 10mm copper pipe, another fermentation bucket (or any bucket of ~20-30 liters) and an air lock gasket. Wound the pipe to a spiral that comes from the lid, goes into the bucket and exits from the lower edge of the bucket through airlock gasket. Takes ~15-30 minutes to build one. To improve the cooling insert a hose to the bucket and have the water flow from bottom to top. You can add a drain to the top part of the barrel to avoid water spilling around.



Pic – Worm in a barrel

Spiral in a tube approach can also be used. Cooling spiral is typically a 5-6mm copper pipe wound to a spiral and inserted to a pipe to cool down the vapors. It's relatively easy to make as it requires no soldering and it's quite effective as well. You can make one by taking a length of pipe (diameter of this pipe becomes inner diameter of spiral), inserting one end of copper pipe through the pipe and winding the rest of the copper pipe around it. After the spiral is wound remove the pipe and you have a single cooling spiral. Leave enough ends to cooling spiral so you can bend them and use them to hang the spiral on the column. It's also possible to make double or triple spiral when larger diameter spiral is needed.

PIC – double cooling spiral

Here's how I made such a head from the left over parts I had lying around (ignore the ball valve, it's leftover from previous build). The 42mm pipe is inserted to capillary joint. Inside the 64mm pipe there's a triple cooling coil made from ~8 meters of 5mm pipe. On top of the T –joint I have a thermometer. The 64mm pipe size is recommended for 4kW, for 2kW 42mm will do just fine

PIC – 4kW pot still head

Same cooling spiral can be used for column and pot still; T-joint in this head can be replaced with 90-degree bend capillary joint. This can even be modified to a cooling management or vapor management head by adding a reflux condenser and a column to the system.

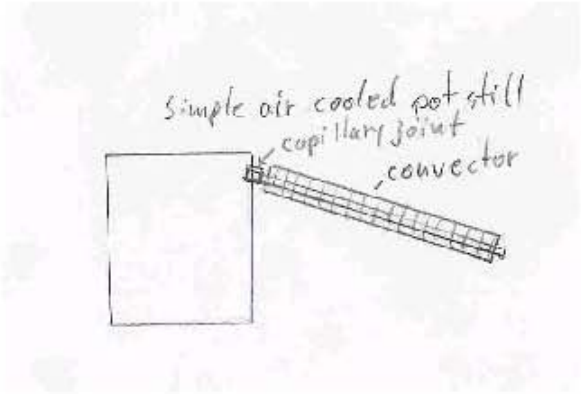
Length of the condenser depends on the power used, type of the condenser, amount of water flow etc. I suggest that you take a look at www.homedistiller.org There is a condenser-sizing calculator that will give you pretty good guesses about the sizing. For those without net access 5 meters of 5mm copper pipe in single or double spiral will cool a bit over 2kW, 1 meter liebig from 15mm pipe cools a bit over 1kW, 8 meters of 5mm pipe in triple spiral will (just) cool ~3800W (all fed from regular water mains at a bit over 1 liter / minute). To make a slow pot still you could use

~700W heating element, uninsulated fermentation bucket and ~35cm long liebig condenser (jacketed part length) from 10mm pipe that goes through the air lock gasket. This would only use ~7 liters water / hour.

Air-cooled:

Sometimes arranging cooling water is somewhat problematic, or using water causes other types of problems. In such case a spiral still (Appendix 2 and for complete document http://distillers.tastylime.net/library/ or www.bryggforum.com) or using convector pipes for condenser are pretty good solutions. Convector pipes are typically used in mobile homes as heating radiators. 2 meters of 22mm aluminum convector pipe costs ~30 euros and cools off ~1600W with uninsulated boiler (25l SS kettle in this case, assumed power losses ~500W) meaning they can cool ~400W / meter with natural convection. Adding a fan to push air through the convector pipe will increase the efficiency further. For example you can purchase a short length of 22mm ID silicon hose and use that to connect the convector pipe to boiler. Even simpler, use silicone and some SS clamps or similar to attach a 22mm capillary joint to the top side of the boiler at slight downwards angle and connect the convector pipe to the joint with Teflon tape. Or for more professional approach solder a small collar to the joint and attach it with SS screws and silicone to the side of the bucket.

PIC - convector pipe



PIC – convector + fermentation bucket

Another alternative is to use ~5 meters of 10mm pipe as in worm in a bucket condenser. Wind that to a spiral that fits inside a 110mm or larger drainpipe, insert into the pipe and attach a large computer fan or similar to the other end. Effectiveness depends on fan power and pipe length. 5 meters of 10mm pipe will cool ~300W with natural convection, so with good fan you should be able to cool over 1000W.

How to operate pot still is explained in whiskey chapter. The same operating procedure can be applied to brandies and rum.

Reflux stills

Reflux stills (here this is interpreted as stills with column(s) and reflux condenser(s)) are best used for making pure ethanol. They can be used for flavored drinks as well, but IMO this requires lots of experience and accuracy for bearable results and is not recommended for beginners.

Columns

The most important part of a reflux still is the reflux column. The purpose of column is to provide a place where multiple distillations can occur resulting separation of different compounds in the vapor with lightest boiling point compound on the top. For this purpose the column needs to be filled with a material that allows multiple condensations and vaporizations to take place. To make all this work a considerable amount of vapor needs to be condensed at the top of the column and returned back to column. The ratio of condensate or vapor returned/removed is called reflux ratio. I won't go into theoretical details on this subject, just give guidelines of best practical approaches for making a column known at the time I write this document.

Size of a column – size does matter

Column sizing is very crucial for efficient still. A column is usually a pipe filled with proper packing. A proper diameter and length of this pipe must be selected for each still.

The length of the column is mainly dependant of the packing type and the amount of reflux used. Good packing requires less column height. High reflux ratios (lot's of vapor condensed and returned to column) require less column height. To play it safe use good packing and a column height of 70cm-1 meter. I've used 30cm column, and while it works OK the reflux ratio needed to be high which meant slow product output. I've tried 1.5 meters column as well, and while it worked great there was not that much difference to a 1-meter column. If you are after ultimate separation make the column as high as fits and use good packing. If space is limited, short columns will work when run slow enough.

The width of the column. The most important factor when determining column width is the speed of the vapors inside the column. This actually translates to the time vapor spends inside the column doing condensation/evaporation cycles, but vapor speed is good and "easy" to calculate indicator for that. It needs to be kept low enough so that vapors have time to condense and re-evaporate several times during the passage. It is also an indication of how much vapor and reflux fits inside the column, if there's too much the vapor will push the reflux out of the column or at least cause a phenomena known as choking. Following recommendations are for mesh/scrubber type packing. As a rule of thumb a vapor speed of ~20"/s is the highest one should use. With higher speeds the separation suffers and the column may experience flooding, choking and other problems. ~12"/s is a very good speed and as low as 5"/s have been used with great success. There could be a lower limit for the speed, but in practice it's normally not reached. Now to use these numbers you need to calculate the vapor speed. Variables used are power in Watts and area of column circumference in square mm. The area can be calculated from the following formula:

D = diameter of column in mm
A = area of column
A = 3.14 * D/2 * D/2

The vapor speed:

W = power in watts
A = area of column from previous formula

Vapor speed = W * 750 / A * 25.4 = W * 750 / (3.14 * 25.4 * D/2 * D/2)

The easiest way to use the formula is to enter it to a spreadsheet and experiment with different values. If the power is fixed you need to adjust the width of the column and vice versa. You should note that these calculations are for the power actually “fed” to the column. Typically some power losses do happen and they need to be taken into account. As an example a 25 liters SS stockpot loses ~500W when uninsulated while uninsulated fermentation bucket looses ~300W.

To get most out of your column you should insulate it very well. If the column is left uninsulated vapors will condense on the column walls leading to reflux running down the column walls and not re-evaporating, as it should. This will cause poor separation, disturb the equilibrium inside the column and lead to decreased performance. Pipe insulation is available at most hardware stores for relatively low price (few euros / meter of insulation tube).

Columns wider than 3” are a bit of a gray area with mesh filling. Channeling is more likely with wider columns, which leads to a poor quality. This can be countered by using reflux spreaders in the column. Another option is to use multiple columns, for example four 2” columns have the same volume as one 4” column assuming similar lengths. Add a chamber on top of the columns, VM head from the chamber and a condenser on top. If you try a packed column wider than 3” we would like to hear how it works.

Packing

After proper column size is selected it’s important to fill it with efficient packing. IMHO there’s only two choices of proper packing for regular hobbyist: pot scrubbers made of copper or stainless steel, or alternatively copper mesh packing from amphora society or other vendor. The mesh packing is slightly more expensive but it works better on wider columns. Raschig rings are quite expensive and not nearly as effective. Laboratory type packings (propak helicoil etc.) are more efficient but the price is IMO way too high. So get scrubbers or mesh and pack the column evenly with it. You need to be able to breath through a packed column, if you can’t the vapor won’t pass either.

Still head design

There’s 3 basic ways to do the return of reflux and product removal: Liquid Management (LM), Vapor Management (VM) and Cooling Management (CM). In this case I consider power management as a sub case of CM. All the methods work well and have their advantages and disadvantages. A common feature to all these designs is a reflux condenser on top of the column (relatively, it can be elsewhere but the reflux is fed to the top of the column).

LM:

- Quite easy to construct
- non constant reflux ratio
- can be used for flavored spirits
- Quality gets worse towards the end of the run unless reflux ratio is increased
- One valve to control

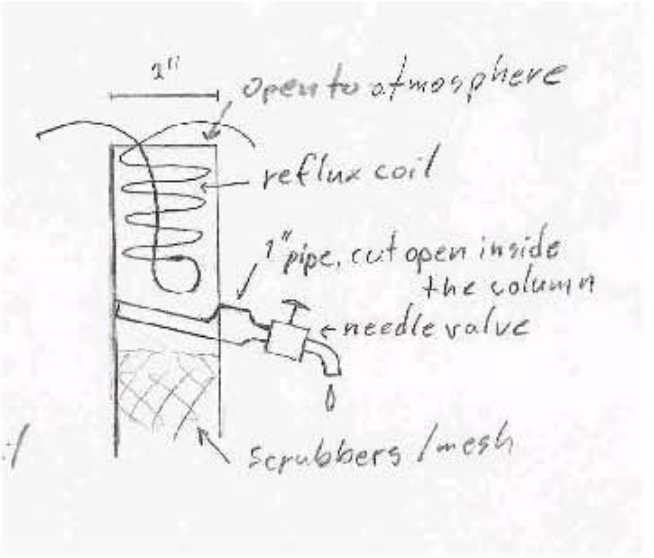
VM:

- More work to build
- automated shutdown at the end
- reflux ratio increases towards the end
- not good for flavored spirits
- can't collect lower than ~47% output
- one valve to control

CM:

- More work to build
- automated shutdown at the end (if so adjusted)
- shutdown between heads, main run, tails possible
- reflux ratio increases towards the end (if cooling kept constant)
- can be used for flavored drinks
- Controlled by adjusting cooling flow in reflux condenser
- Alternative method, constant reflux cooling and control power

In LM we control the ratio of condensed vapor returned to column / removed as product by physical means. This usually means that all vapor is condensed and some part of it is removed via adjustable valve. There are lots of designs for this type of heads, Nixon-Stone / offset head and Bokakob's designs being the most common types. In principle we have a reflux condenser somewhere over the packing. This condenses the entire vapor and returns it back towards the packing. On the way we have a liquid trap that all or most of the reflux must pass. At the bottom or side (or wherever) of this trap there a takeoff point where we have a valve to adjust the takeoff rate. Needle valves are used for their accuracy, but they can be substituted with ball valves if necessary. Here's a drawing of one version that I think is not plagued by copyright issues.



PIC-LM

An interesting modification of LM is reflux management, where we control the amount of reflux returned to the column. This leads to increased reflux ratio towards the end of run and can achieve automated shutdown. A further refinition of this technique is called Automated Reflux Control (ARC) and there's an entire chapter on building this type of system.

Vapor management is a technique pioneered/invented by Mike Nixon and Mike McCaw. In VM we control the amount of vapor removed / condensed. VM is based on the fact that when vapor contains more than 47% alcohol it's heavier than air and will flow downwards. Thus we provide for the high % vapors an exit path at the top of the column. At the top of the column there's again a reflux condenser that condenses all vapor reaching the top and in this case returns it directly to packing. Below that there's an exit for vapors where we typically use a gate valve or large ball valve to control the removal rate. After the valve there's a 90-degree turn down and a vertical product condenser.

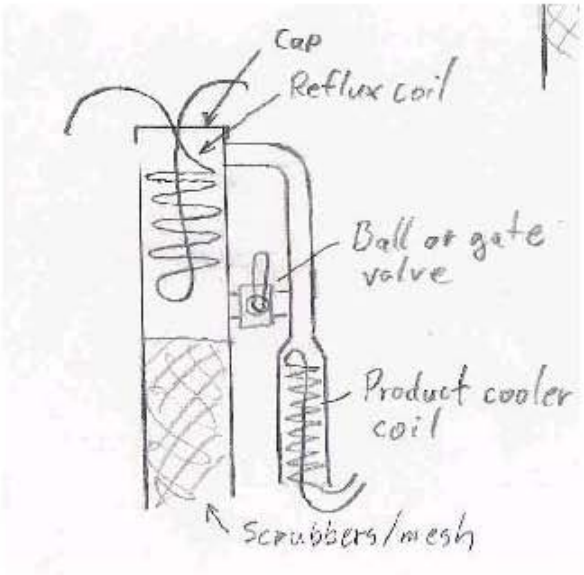
Both previous designs have a reflux condenser at the top that condenses all the vapors. When some of the vapors are allowed to pass the reflux condenser and condensed after that as final product we are talking about cooling management. Traditionally this design is perhaps the most complicated of these methods, although it can be made quite simple, as we will show later. To let the vapors pass the reflux condenser we can either reduce the cooling or add power. Traditionally cooling management systems have been water-cooled and adjustments have been made via flow rate of cooling water. Another alternative is to use constant cooling rate and control the heating power.

An example of such constant cooling system is a spiral still with column as described in appendix 2. An improved version for higher power can be built with convector pipes as shown in following picture (note vertical positioning of convector requires a fan to move the air through convector).

PIC – convector head

PIC - horizontal convector head

A water-cooled version of such system can be built in several ways. One example that combines both CM and VM is shown in following drawing.



PIC –VM-CM combo

It is also a good idea to have thermometer at the top of the column to help controlling the still operation. It should be situated above packing near the product collection point.

Another important thing to note, when the reflux is returned to packing it should always flow to the middle of column or close to it. If the reflux is running down the column walls you can use a small collar above the packing to guide it to middle.

PIC - collar

Condensers for reflux columns

The most typical condenser found in reflux stills is actually the coil type condenser that was already discussed in relation to pot stills. The good thing about coil is that it requires no soldering, you can as an example use garden hose fittings glued to the ends with epoxy to feed the water. Bending could be somewhat problematic, I have made coils with ~30mm outer diameter, but in practice 40mm and larger coils are much easier to do. For larger coils there's a possibility that vapor will flow through the void inside the coil, to prevent this people have stuffed a pot scrubber inside the coil or used some other method to fill the void. Liebig condenser is naturally one option, although

height might be a problem. One very efficient way of cooling is to make a short and wide (40mm or more) ID liebig and put a reflux coil inside it. This is called gloved cold finger. With these three approaches most of our water-cooled condenser needs can be solved.

Now for the air-cooled condensers, copper pipe and different convector pipes can be used to provide variety of different condensers for our needs. Copper spiral is one easy to make condenser type, although you need quite a lot of pipe to achieve good cooling power. Another problem for reflux condensers is flooding due to small pipe diameter. Here are some rules of the thumb power to pipe diameter ratios:

Power to condenser 200W minimum ID 8mm typical OD 10mm
300W 10mm 12mm
500W 13mm 15mm
750W 16mm 18mm
1200W 20mm 22mm

Note: you'll have to count in the power losses due to insulation deficiencies. Uninsulated 25L SS pot will lose ~500W, similar fermentation bucket made from plastic loses ~300W. Uninsulated column loses typically ~200W. It's very difficult to achieve perfect insulation so you'll have to always assume 100-200W losses even when insulated well. I usually leave my boiler uninsulated since they are much easier to wash and handle that way.

One interesting approach pioneered by "kilju" from bryggforum is to attach several pieces of copper wire to a pipe so that it looks like a giant bottlebrush. This can be achieved by hose clamps or soldering. This option is more efficient than aluminum convector pipes and certainly worth considering if you have trouble locating convectors. Watch out for the weight though.

The easiest alternative to make a reflux condenser is to make/buy a cap for the column, stick a 90 degree capillary joint through it at slight upwards angle and solder it in place. A picture of such enterprise is presented in ARC paragraph. Another quite simple way is to make a hole to the topside of the column and solder a straight capillary joint to that on slight upwards angle (note column needs to be capped for this to work). To these joints a convector pipe or spiral can be attached with PTFE tape making the system easy to disassemble for storage. Convectors can also be used on vertical position if a fan is used to blow air through them.

Automatic Reflux Control (ARC)

The newest gizmo in amateur distillation is ARC, which is generally used to control a regular LM head. The idea in ARC (to my knowledge first introduced by “Farbror Plast”) is to use the temperature at the top third (or so) of packing to control the output/reflux ratio. The actual system is amazingly simple and can be attached to most LM heads. Here are few pictures of building an external pipe version.

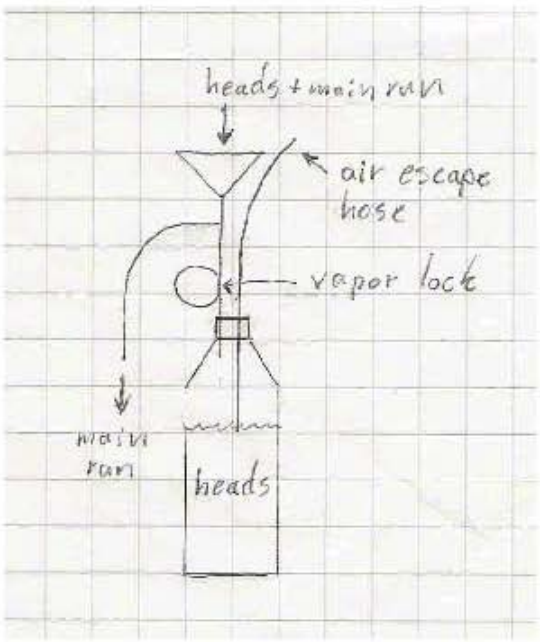
PIC – EL-ARC – note, sensor pipe was lengthened later

From LM heads product takeoff you have a copper pipe (8-10mm have been successfully tested) that is sealed at the bottom end, goes down 80% of packed column height (i.e. 80cm pipe for 1 meter column) and is soldered to the outside of column pipe to get good heat transfer. About 20 cm from the top of the pipe is the actual products take off. From the takeoff we have vapor lock and the pipe goes up again to 1-2cm below the liquid surface on LM reservoir and back to collection vessel. On the highest point of this product takeoff is a ventilation hole to prevent siphoning (required for at least smaller pipe diameters).

Note, in the picture I have used silicone hoses. I recommend you use a 5-6mm copper pipe instead.

The principle of operation is that the liquid at the bottom of the 80cm pipe will boil if the temperature at the lower parts of the column where the pipe is attached is higher than the boiling point of liquid inside the sensor pipe (in practice 78.1-2C since it's the first stuff that reaches the top of the column). When the liquid boils no liquid will enter the product takeoff tube, but all is returned to column via LM head due to pressure difference. When the temperature at the column (in the part where the pipe is soldered to) evens out the boiling stops and liquid will start to flow out of the product takeoff. This causes less reflux and the temperature in the lower part of the column starts to rise. When it's high enough the output stops and the cycle starts again. In practice this works very well. It adjusts the reflux ratio automatically and stops the collection before any higher boiling point alcohols have a chance to get to the top of the packing.

This system gets rid of the tails but there is still the problem with heads. Several methods to get rid of the heads are researched, but I'll present here the simplest one.



PIC-heads-collection-bottle

With this system the heads will go to the bottle, and when it's full to the set limit (ventilation hose/pipe inside the bottle) product will start to flow to the collection vessel. The amount of heads can be adjusted by varying the length of the hose/pipe inside the bottle. The ventilation pipe/hose needs to go above the point where pipe to product vessel leaves, as liquid inside the ventilation pipe will rise to this level. The vaporlock in the tube prevents heads in the bottle from contaminating the product and also enables the adjustment by vent pipe. Otherwise the liquid in the bottle would rise up to the actual feed tube bottom. I recommend this type of system to be built from 8mm pipe as minimum diameter.

PIC-Heads collection bottle in practice (built from leftover parts).

So, an example of easy to operate system at the time I write this (actually my current test rig):

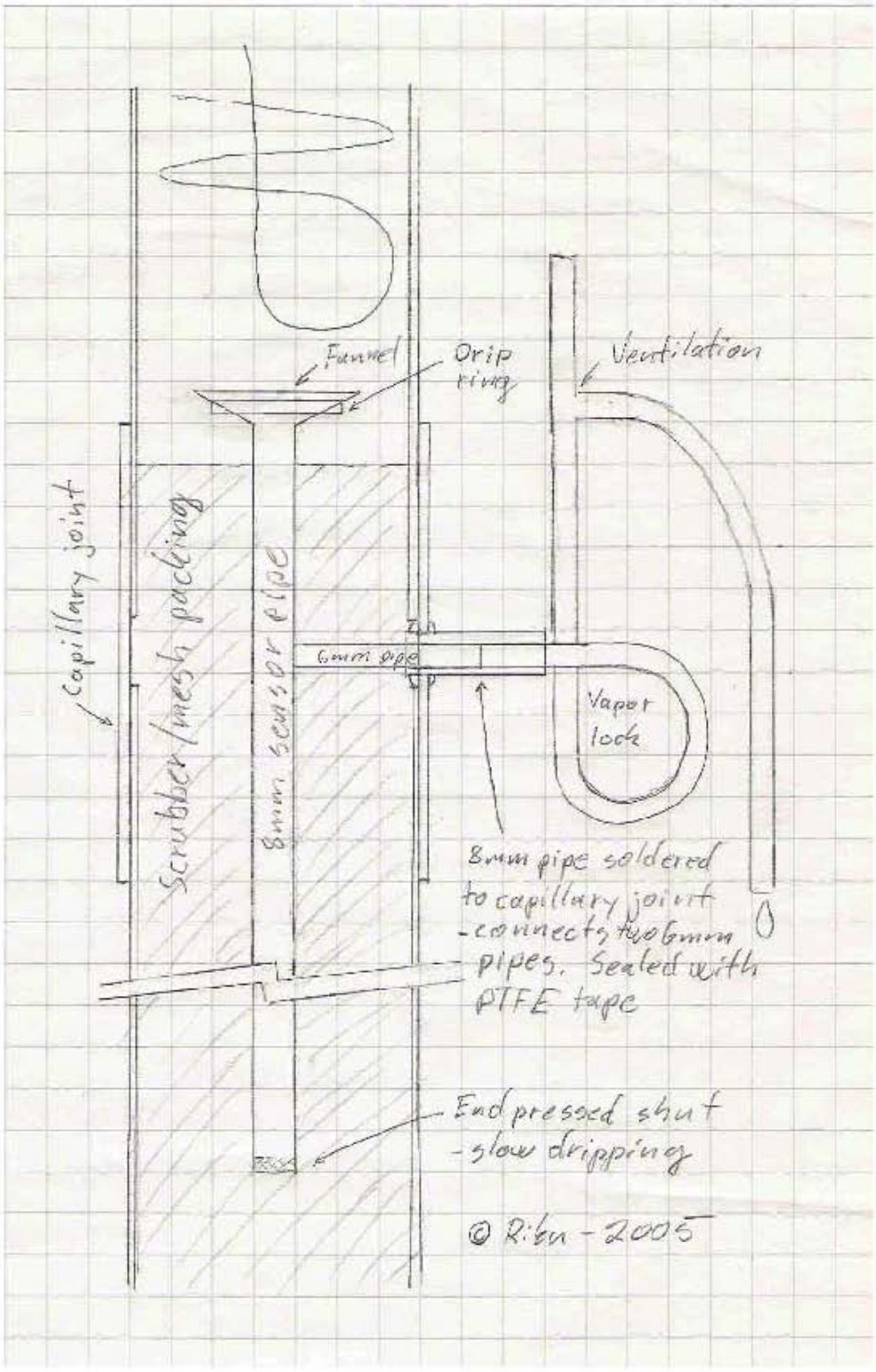
1.6 meter column, ~40mm wide
700W power (uninsulated fermentation bucket)
1-meter (or a bit more) convector pipe for reflux cooler
ARC to control product takeoff (internal sensor pipe is nice)
Bottle system for heads

Fill the boiler, set up heads collection system, turn on the power and let it run. After 14 hours or so (could take a bit more) turn off the power, store heads, empty and clean the still, dilute the ethanol and enjoy the product.

A limitation of external sensor pipe ARC is that it won't work well with high % (over 20%) mashes. To counter this problem an internal sensor pipe can be used. After some trial and error I constructed following simple to build modular system that has worked very well.

To start with I have a 40cm piece (for 1 meter column, 60cm for 160cm column) of 8mm copper pipe. It's pressed shut at the lower end, this allows slow dripping of contents meaning that heads won't stay at bottom of the pipe. At the top I have a double funnel (or funnel with drip ring) where reflux from condenser drips to (you may need a small guide or collar to direct drips to funnel). The ethanol that's not removed via ARC will overflow and drip from the bottom of the funnel/ drip ring to the packing around the sensor pipe. ~6cm below the funnel top we have a product takeoff from sensor pipe. This is a 6mm pipe that goes through the capillary joint and has a vaporlock and ventilation hole arrangement outside the column, just like with external sensor pipe version. Through the capillary joint you can solder a piece of 8mm pipe. 8mm pipe can be used as a

capillary joint for 6mm pipes (seal with PTFE tape) meaning that you can make modular system as shown in picture where the external parts can be removed during disassembly. Another good thing about such setup is that you can use this to adjust the height between LM reservoir and highest point of product takeoff (i.e. actual take off rate). By turning the entire external vaporlock system to an angle in relation to column centerline you can lower the highest point of takeoff tubing and increase the takeoff rate. This is very useful in fine-tuning the system performance. Once it is set you can mark the angle and duplicate the setup for consequent runs. After building this just wrap some mesh/scrubbers around the sensor pipe and insert it into the column. PTFE tape is again used to seal the joint and column is filled from below for the rest of the packing. In my tests I was able to halve the amount of heads by using this version when compared to external pipe version. When tested with 160cm column and 60cm sensor pipe it produced extremely pure ethanol and ceased output before any tails did appear. With 100cm / 40cm combo the ethanol was very good but there was a very faint sweet taste from burned sugar.



PIC – drawing of internal pipe ARC

PIC – internal pipe ARC in practice

PIC – Fine-tuning ARC output

Now the latest innovation for removing heads (pioneered by “Farbror Plast”) is to use separate heads column for that. In practice this means that we have another column that’s closed at the bottom and the bottom of that column goes down to mash in boiler. This gives enough heating for the column to let it operate normally. The product from ARC column goes to top of packing of this heads column. At the top of the column we have condenser as usual, and below the condenser we have a reservoir of 100-150ml where heads will be collected. The pure ethanol is taken out from the bottom of the column. Now the biggest problem with this type of approach is that at the start the column is fed with lots of heads and at the end there’s mostly pure ethanol. This means that we need to give the column some time to stabilize before we start taking product out. Two methods for this have been identified so far:

1. We let the ethanol pool at the bottom of the column and when adequate level is reached it starts to flow out. Finding a proper level requires experimenting but this has been tested to work.
2. We collect all the reflux below the packing and feed it back to column via needle valve. When there’s enough reflux flowing the needle valve will restrict the flow and some pure ethanol will start to come out.

These methods are still experimented with and I’ll publish the results when I’ve found a method I’m happy with.

Controlling heating power

There are lots of methods for controlling the power used to heat the boiler. It is to be noted that the author is not an expert in electrics/electronics, and we take no responsibility of possible problems caused by the use of described methods.

The simplest way is to add or remove insulation to the boiler to adjust heat losses. This is somewhat clumsy way and it lacks accuracy, but it's the easiest way and can be used ad hoc when needed.

Another relatively simple way is to use 2 or more heating elements and switch them on/off or connect them parallel/serial to have variety of different heating powers. A nice sketch and description of doing such a system is described in Mike Nixon's book The Compleat Distiller.

The most sophisticated way is to use a separate power controller to adjust the heating power of the element. Up to 300W elements you can buy ready made light bulb dimmers at relatively low cost. When more power is needed the availability of power controllers is more limited and the price goes up. A problem when regulating large power elements is electromagnetic interferences and interference to local electric network. It's therefore essential that properly designed power controller that is meant for the task is used. For example it's quite important that the power controller has zero-crossing switching. This means that the power is switched on/off only when the sinus waves of electric mains are at zero, thus not causing previously mentioned interferences.

The method we have used is computer controlled solid-state relay with zero-crossing switching. This is relatively easy way to do it and requires little understanding of electronics.
Parts:

One solid-state relay with zero-crossing switching. 10A relay is enough for 2400W (max. for regular household fuses), 16A goes for 3800W and 20A is enough for 4800W (7 euros or more).

One parallel port connector

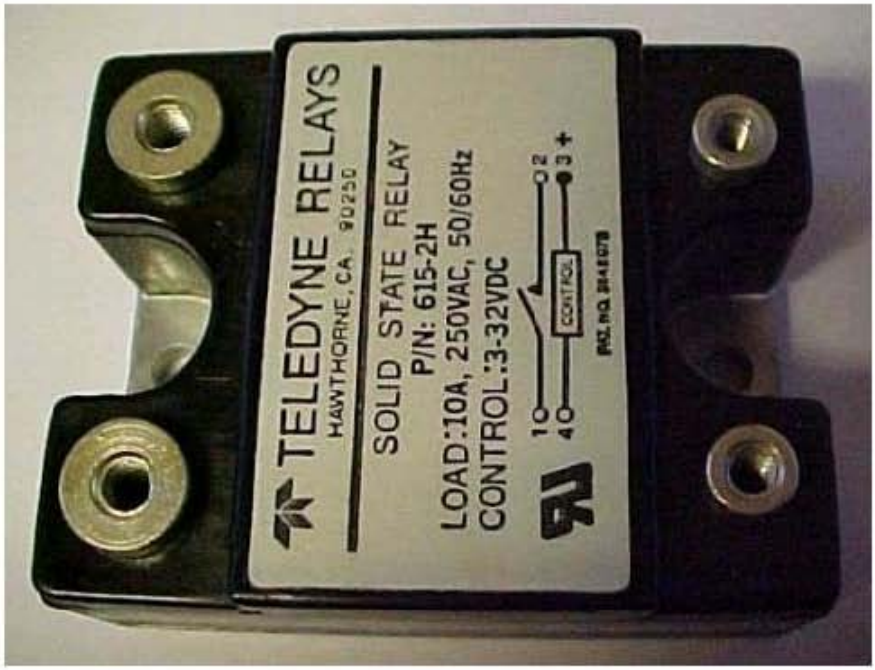
Length of cable (1-2m) with ~4 wires or more

Soldering tin + flux

Computer with parallel port

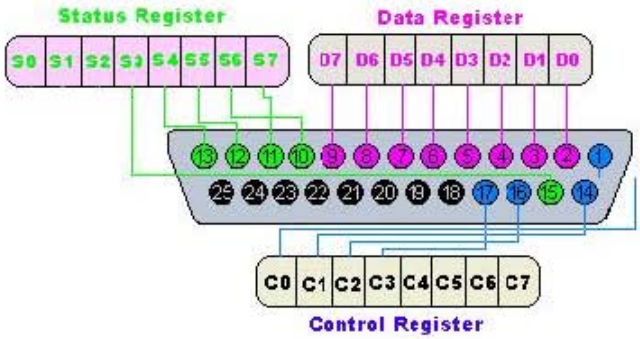
Some understanding of computers and programming

A solid-state relay is quite simple thing really. It has two connectors for high amp power and two connectors for low amp power. Feeding power to low amp connectors make the high amp connectors connect to each other thus switching on high amp power. Switching off the power to low amp connectors switches off the high amp power. Zero-crossing switching makes sure that interferences to electric mains or radio frequencies should not happen.



PIC - Solid state relay

In order to operate the relay it needs to be connected to a computer. In my case I used the parallel port of the computer, but other ports may be used as well. The pin configuration of a parallel port is presented in following picture.



PIC – parallel port (from logix4u)

There are ground connectors and connectors that can be switched to 0 or 5 volts. Basically we can take one 5V pin and a ground pin and connect those to the control connectors of a relay. There are few problems though. The power provided by the parallel port pins is quite low, and it may not be enough to switch the relay on. To overcome this one may need to connect several 5V and several ground pins together. Another problem is possible damage to the parallel port due to too much power or other reasons. Using diodes in pin lines may solve this, although we chose to skip this step as we are using an old computer destined to scrap sooner or later. Here’s the list of pins:

Pin No (DB25)	Signal name	Direction	Register - bit	Inverted
1	nStrobe	Out	Control-0	Yes
2	Data0	In/Out	Data-0	No
3	Data1	In/Out	Data-1	No
4	Data2	In/Out	Data-2	No
5	Data3	In/Out	Data-3	No
6	Data4	In/Out	Data-4	No
7	Data5	In/Out	Data-5	No
8	Data6	In/Out	Data-6	No
9	Data7	In/Out	Data-7	No
10	nAck	In	Status-6	No
11	Busy	In	Status-7	Yes
12	Paper-Out	In	Status-5	No
13	Select	In	Status-4	No
14	Linefeed	Out	Control-1	Yes
15	nError	In	Status-3	No
16	nInitialize	Out	Control-2	No
17	nSelect-Printer	Out	Control-3	Yes
18-25	Ground	-	-	-

What I did was bundle pins 2-6 together and connected them to terminal 3 in the relay (see pic.). Then I bundled 18-20 together and connected those to terminal 4. Terminals 1 and 2 are connected to one of the power lines to cut the power when needed.

PIC – power controller system, relay under the black tape

Note, it is extremely good idea to cover the high amp terminals with resistant material. Using a separate non-conductive box is recommended. Also on the picture there's a short strip of copper connected to relay's metal base to aid cooling in prolonged operation.

Now we need to get the computer to switch the voltage of parallel port. In our case we were running windows 2000 OS, and we will present our example for that and compatible OSs. The basic idea for our power control is to switch the power on and off at certain intervals to regulate the power. The frequency of electric mains is an important factor in determining the intervals needed. In our example the mains frequency is 50 Hz. This means that the zero crossing happens 50 times / second, or every 20ms. Based on this we choose our basic time slot to be 20ms, which translates to a total cycle of 2s divided into 100 timeslots of 20 ms each. We turn the power on for x number of timeslots and turn it off for 100-x number of timeslots. Now when heating a still we are lucky that there is typically a mass of 25 liters of liquid surrounding the heating element, which masks small variations and allows us to use such a long cycle. Our only requirement is to avoid surge boiling, and our experience has shown that it doesn't happen in described conditions.

To write the actual program we tried to make it simple and cheap. For that purpose we used C language and Borland's command line compiler (available for free at http://www.borland.com/bcppbuilder/freecompiler). This program can be run as command line application and has been tested for several days in a row in actual production.

To run this program in newer versions of windows (e.g. NT, 2000, XP …) a dynamic link library inpout32.dll is needed. This dll with lots of additional information can be found at http://www.logix4u.cjb.net/ . To use this sample with other OSs some modifications to the source code are required. The source code is in Appendix 1.

Making a sugar mash

Making a sugar mash is nowadays amazingly simple, buy a packet of turbo yeast and sugar and follow the instructions in yeast packet. Basically you dissolve 6-8kg of sugar in few liters of water (pour boiling water on top of the sugar in fermenter and stir) and top the fermenter up to 25 liters with colder water. Add yeast and yeast nutrients, stir and let it ferment for 4-8 days. Although turbo yeasts promise 24-48 hours fermentation it's a good idea to have few days extra time to reduce the number of leftover sugar in a mash and to let the mash settle a bit. If turbo yeasts are not available regular bakers yeast can be used for mashes up to ~14%, but in this case additional nutrients are needed. Check www.homedistiller.org for additional information on using bakers yeast. As a rule of thumb you'll get ~0.6 liters of alcohol from 1 kg of sugar assuming complete fermentation.

Running the still for pure ethanol

Building a still is pretty straightforward. Running the still to get pure ethanol out is actually an art (although things like ARC make it much easier). Here are some thoughts about the subject.

Stripping the mash (optional)

First lets assume that you have used a turbo yeast and sugar to make a mash of 14-18% alcohol in it. It can be distilled straight away with reflux still, but towards the end of the run there's the possibility that leftover sugars and yeast will start to burn and give off flavors. This can be avoided by clarifying the mash (like in making wine, gelatin, egg yolks etc. can be used) or doing a stripping run. For stripping run a pot still is great, amazing still works good as well or you can use derefluxed LM or CM still (for LM max. product out, for CM no reflux cooling). The idea is to quickly reduce the amount of mash to one third or so, get higher starting alcohol % and get rid of the yeasts sugars and other impurities in mash.

Ethanol run

Now we'll load the stripped or non-stripped stuff into the boiler, assemble the still and start running the thing. One thing to note, if you have high % low volume mash make sure you'll have enough water left to cover heating elements at the end of the run. First we need to get the content to boil. Boiling temperature depends on the alcohol % of the mash. Pure azeotrophic ethanol boils at 78.2C and pure water at 100C, our starting temp will be somewhere in between. When the mash nears the boiling it's a good idea to turn on the cooling if water or fans are used. You can turn them on at the start but getting a 25 liters mash to boil will take from ~30 minutes at 4kW up to 8 hours with 300W.

When the mash boils vapor starts to enter the column it'll slowly creep up and when on top you'll see it from the thermometer (provided you have one).

Note, following information does not apply to ARC.

When the still is warm you should let it run for a while at full reflux (i.e. no product is taken out) to let the lowest boiling point alcohols cumulate at the top. This is called equilibrating and it may take from 10 minutes to few hours. 30 minutes is a good value to start with. When equilibrium is reached the temperature at the top will be below 78 degrees (typically 77.5 or less) and you can start to take off the impurities (heads) very slowly. The speed depends on the power that is used, but 1 drop/second is a good speed to try. When you have collected enough (1-10dl, depends on lots of variables) you will have pure ethanol coming out and you can increase the collection speed and start collecting the middle run. Towards the end ethanol will get exhausted and higher boiling point alcohols will start to appear (tails). These higher boiling point alcohols are one major source of hangovers, they cause especially nausea and mood swings. At this point (or actually a bit before) you should again slow the collection rate (especially on LM) to increase reflux and to get more pure ethanol out of your mash. It's up to you when to start and end collection of main run, but to play it safe you can collect 25% heads, 50% main run and 25% tails (from total theoretical alcohol). With good still and careful running 10-80-10 is certainly doable. Tails and heads can be added to the next mash as they contain mostly ethanol that can be recovered this way. However, the first 0.5dl should

be discarded as it contains mostly hangover (esp. headache) causing congeners (mainly ethyl acetate) and they will accumulate over time if recycled, the tails will not accumulate in a same manner as the overflow is left in the boiler. VM head will automatically stop output and carefully adjusted CM head will do that as well. For LM collection should be ended when head temp is ~82-85C

Tips, to determine cuts by sniffing the product is a good idea. To be more accurate take a small sample and dilute it down to ~35% to get more flavor out. It’s not forbidden to sip as well, but you’ll loose the accuracy after a while ;) If cuts go FUBAR you can always put everything back to the boiler and redistill. First 0.5 dl or so (foreshots) makes a very good cleaning agent for household use.

Making Whiskey

Making whiskey is IMO art of distillation in it’s finest. Pure alcohol production can be pretty much automated, but to make proper whiskey you always need the nose and taste buds of the distiller. Here’s a short description and some examples on how to make pretty good malt whiskey. These are mostly cuts from my writings in internet discussion forums.

Making whiskey from malt can be divided into four stages, mashing, fermentation, distillation and aging. I'll give a short description of each stage to allow you to make your own whiskey.

Mashing, the traditional way is to use malted barley, water and ale yeast. Nowadays many people use readily available malt extracts. Malt extracts are OK, but for best results you should use one without hops (most brands are hopped) and use no sugar (usually means two packages of extract). You can also use corn or corn flakes to make bourbon whiskeys, but that's a lot more work and I won't go into that in this text.

Here’s an example of how to make 25 liters whiskey mash and how to make whiskey from the mash.

For mashing I use a large kettle (more than 10 liters) and 25 liters picnic cooler + thermometer. I heat 10 liters of water with adjusted Ph of around 6 (2ml citric acid to 10 liters of 7.5-8 Ph water) to a temperature of 74 degrees C and pour that over 5 kg of crushed malt in the cooler. Mix thoroughly, check that temperature is 64-65C and close the lid. After ~1.5 hours has passed the temperature should have fallen to ~63C and the conversion to sugars has happened.

The “porridge” is poured into a fermenter and filled to 25 liters with cold water. When the temperature of the mash is below 30C, the yeast can be pitched. After that the fermentation should go on until dry or up to 4 days.

Optionally you can sparge the malt and ferment the resulting wort. For more information about sparging, malting etc. se John Palmer’s www.howtobrew.com

After 4 days we have 25 liters of sour smelling mash that should be distilled. At first a stripping run is done. This is to avoid burning the grains during the next phase, or just to reduce the amount of mash and get % higher if using potstill. For stripping I've used amazing still and collected half the amount of mash. Nowadays I use a potstill made out of a fermentation bucket and use a 2kW element covered with mesh to avoid burnt mash.

With potstill type stripper just fire the still up and collect everything up until the head temp is 98-99C.

Now you can make the actual whiskey run with reflux still or pot still. For light bodied whiskey you can use reflux still as described in Ian Smileys book. From my experience it produces very light whiskeys with a bonus side of little to no hangovers. For regular full-bodied whiskey you either need a potstill or lots of experience with reflux still. A good way to determine proper cuts is to use alcoholmeter and do the cuts by ABV. A good range for pot still is to start the middle run at 75% and start the tails phase at ~55%. This will produce medium bodied whiskey. After you get used to

the tastes and smells in different phases you can do the run by using just your nose to smell the stuff. Heads and tails should be added to the next run to provide additional flavor.

Now the aging and diluting part. Aging is best done at 63-64% alcohol. If the single malt is too strong flavored for your taste you can cut it 50/50 with neutral spirit before aging. Aging is best done with somewhat burned oaks shavings. In my latest batch I used 50% of shavings toasted at ~150C and 50% toasted at ~200C which resulted pretty good flavor. I usually toast them in closed container in the oven for 1-2 hours. Put the whiskey in to jar, add oak (~2dl shavings for a gallon jar) and let it soak. Shake the bottle every now and then. After ~2 weeks you can take it out, but the longer it soaks the better it gets. Adding a splash of sherry will give the impression of used sherry casks like used in aging of black bush etc. You can dilute it down to 40-43% before drinking.

I've used both shavings bought from home brewing store and sticks made from plank of oak. Shavings are faster and you need less of them. Sticks can be used 2-3 times.

I think I should talk a bit more about distillation before everyone starts blaming me about whiskey without taste. The alcohol% based cuts are for double distillation in a pot still. The low wines for the second distillation should be at 25-30% for this to work well. Personally I end the run at ~50% which gives fuller bodied whiskey. If you use amazing still for the stripping the low wines may only be ~15% depending on which type of system you have. In this case I'd rather recommend triple distillation.

Here are some hints for using you nose and tongue to determine cuts (with potstill).

Heads: At the start there's a strong ethyl acetate smell that gradually fades. It's a bit harsh and stingy to smell. While it fades away a beautiful malt aroma starts to appear. This gives a very nice flavor to the main run, but the ethyl acetate present will cause headaches next morning. It's up to you to choose whether to collect or not. Personally I collect the stuff, unless you drink excessive amounts you'll be quite OK. When the malt aroma starts to fade you should start collecting the main run at the latest, unless you are aiming at light bodied late cut whiskey.

Tails: At the end of the main run propyl compounds start to appear. At first they have a very pleasant, a bit "darkish" smell. After a while they start to become harsher and at the end your hair will stand up from smelling it. You shouldn’t be discouraged by the harsh smell, when it blends to main run it gives a very nice aroma to the whiskey. When you get used to the stuff you'll probably start ending the middle cut later.

You can also run by the thermometer, but variances caused by differences in starting alcohol procent in mash and low wines make it pretty inaccurate method.

With a reflux still the separation is much clearer, it takes continuous monitoring to be able to make precise cuts. Also you'll loose some of the whiskey character as some of the lower and higher boiling point alcohols are not collected. I'd recommend reading Ian Smiley's book (making pure corn whiskey) if you want to use reflux still. That's what I started with, and although I no longer agree with all of his text it's a very useful book.

One more tip, if you don't like the product, combine it with heads and tails and redistill. Gaining experience and making notes is essential in this hobby. You learn by doing.

An example, triple distilled Irish style whiskey (NOTE, the third distillation on PP bucket is not recommended due to high alcohol % - hot high % ethanol may soften PP and leach off flavors)(NOTE2, make sure that the heating element is covered when the run ends, add water if necessary):

Stripping run, ended collecting at 98C, end product (low wines) at 30%

Combine several stripping runs for one second run.

Second distillation, low wines at 30%, end collecting at 98C, end product at ~50% (ended collection a bit late due to thermometer problems).

Added feints from previous runs, total amount in boiler ~8 liters.

Third distillation, collected heads ~5dl, started main run at 85%, thermometer reading 82C, actual cut determined by smell/taste (a bit early cut actually). Main run of 4 liters at 81%. Tails started at ~65% thermometer at ~89C. Up until 92C collected in separate bottle (5 dl) for final mixing of the product. Ended collecting at 95C.

After sampling decided to add 2dl from the first (5dl) tails bottle to the main run. Divided the main run into two gallon bottles, diluted to 64% and topped up with 64% neutral spirits. Added handful of toasted oak shavings (50% at 150C, 50% at 200C). Left to age for several weeks. Bottles are stirred once a day or so. The end result was very good, quite similar to Black Bush (which I was trying to imitate) although a splash of sherry wouldn’t have hurt.

This 8 liters of cask strength whiskey was later diluted to 12 liters of 42% high quality whiskey that unfortunately didn’t last that long due to bloody good taste of the product.

Appendix 1, source code for power controller:

```
/*************************************************/
/***                                         ***/
/*** TEST.c  -- test interface to inpout32.dll  ***/
/***  ( http://www.logix4u.net/inpout32.htm )   ***/
/***                                         ***/
/*** Copyright (C) 2003, Douglas Beattie Jr.    ***/
/***                                         ***/
/***    <beattidp@ieee.org>                  ***/
/***    http://www.hytherion.com/beattidp/     ***/
/*** Modified for powercontroller use byabbababbaccc@yahoo.com ***/
/***                                         ***/
/*************************************************/


/*********************************************************/
/*                                                       */
/*  Builds with Borland's Command-line C Compiler      */
/*    (free for public download from Borland.com, at   */
/*  http://www.borland.com/bcppbuilder/freecompiler )  */
/*                                                       */
/*   Compile with:                                       */
/*                                                       */
/*   BCC32 -IC:\BORLAND\BCC55\INCLUDE -LC:\BORLAND\BCC55\LIB TEST-improved.C */
/*                                                       */
/*                                                       */
/*  Be sure to change the Port addresses              */
/*  accordingly if your LPT port is addressed         */
/*  elsewhere.                                          */
/*                                                       */
/*********************************************************/



#include <stdio.h>
#include <conio.h>
#include <windows.h>
#include <time.h>
#define sleepy Sleep /*SystemFunction006 document the internal API */
WINBASEAPI VOID WINAPI Sleepy(IN DWORD dwMilliseconds);

/* Definitions in the build of inpout32.dll are:          */
/*   short _stdcall Inp32(short PortAddress);             */
/*   void _stdcall Out32(short PortAddress, short data);    */


/* prototype (function typedef) for DLL function Inp32: */

    typedef short _stdcall (*inpfuncPtr)(short portaddr);
    typedef void _stdcall (*oupfuncPtr)(short portaddr, short datum);

int main(void)
{
```

```
    HINSTANCE hLib;
    inpfuncPtr inp32;
    oupfuncPtr oup32;

    short x;
    int i;
    int count;
    long click;
    double slot = 2000;
    double power =75;
    char input;

    /* Load the library */
    hLib = LoadLibrary("inpout32.dll");

    if (hLib == NULL) {
        printf("LoadLibrary Failed.\n");
        return -1;
    }

    /* get the address of the function */

    inp32 = (inpfuncPtr) GetProcAddress(hLib, "Inp32");

    if (inp32 == NULL) {
        printf("GetProcAddress for Inp32 Failed.\n");
        return -1;
    }


    oup32 = (oupfuncPtr) GetProcAddress(hLib, "Out32");

    if (oup32 == NULL) {
        printf("GetProcAddress for Oup32 Failed.\n");
        return -1;
    }


/***************************************************************/
/* now test the functions */


time( & click);
printf("press a to add 1%\npress z to decrease 1%\npress s to add 10%\npress x to decrease 10%\n");


for (count=0; /*count < 10 */; count++)
{
    /*****  Power down */

    if (kbhit())
    {
 input = getch();
 if (input=='a')
  power++;
 if (power>100)
  power = 100;
 if (input=='z')
  power--;
 if (power < 0)
```

```
 power=0;
if (input=='s')
 power=power+10;
if (power>100)
 power = 100;
if (input=='x')
 power=power-10;
if (power < 0)
 power=0;
   }
   i=0x378;
   x=0;
   if (power < 100)
{
    (oup32)(i,x);


    /***** And read back to verify  */
    x = (inp32)(i);
    printf("\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\bread (%04X)= %04X power at
%d%%",i,x,(int)power);

    sleepy(slot-((power/100)*slot));
}
   if (kbhit())
   {
input = getch();
if (input=='a')
 power++;
if (power>100)
 power = 100;
if (input=='z')
 power--;
if (power < 0)
 power=0;
if (input=='s')
 power=power+10;
if (power>100)
 power = 100;
if (input=='x')
 power=power-10;
if (power < 0)
 power=0;
   }
   /*****  Power up */
   if (power > 0)
{
    i=0x378;
    x=255;

    (oup32)(i,x);


    /***** And read back to verify  */
    x = (inp32)(i);
    printf("\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\bread (%04X)= %04X power at
%d%%",i,x,(int)power);

    sleepy((power/100)*slot);
}
```

```
}
time( & click);
printf("\ntime %d",click);
printf("\ncount: %d", count);
    FreeLibrary(hLib);
    return 0;
}
```

Appendix –2: Spiral still with column – getting a good separation

This is a text I wrote few years ago but I'll attach it here to provide another simple air-cooled still head. Nowadays I use a hotplate with solid-state relay based power controller to drive this, but the immersion heater and dimmer might be a good option for some distillers.

While spiral still in itself is beautiful work of innovation in it's simplicity and delivers over 95% alcohol when operated properly it lacks one property of compound stills, good separation of

different alcohol components in a mash. As I like the low power, air-cooled approach I decided to take the next logical step and add a column to the system.

Construction

I used a 30cm piece of 40mm pipe for my column as I had it handy, but sizing of a column can vary. There are few issues to consider when building a column.

First of all the column length, if you want to play it safe I'd recommend a column length of 90cm or more. My 30cm column works well, but it requires slow output (lots of reflux) to do it's job properly.

Insulation, to get good separation it is necessary to insulate your column well. Good insulation prevents condensation at the inner surface of pipe, which in turn causes reflux to run down at the pipe surface instead of packing. If this happens it decreases separation efficiency.

For the diameter of column there are few issues to deal with. Vapor speed is the first and most important one when good separation is needed. Basically the lower the speed the better the results as far as my empirical research and information from others go, but with long columns under 20inches/s is OK. With the 300W max power we use, one-inch (or ~25mm, a common pipe size) diameter gives vapor speed of 18 inches/s, so basically that's the narrowest pipe I'd recommend for full power. With proper insulation 5 meters of spiral will not condense all 300W, so we are practically using 200-250W through the column when heat losses or other methods of power adjustment are counted in. With 200W 20mm column will do. My 40mm column and ~250W power gives vapor speeds around 5-6 inches/ second and works well, so larger columns are recommended.

Now column filling, in my case I used a combination of 15cm amphora copper mesh (http://www.amphora-society.com/) + few SS pot scrubbers since that's what I had left over from my previous projects. Both scrubbers and mesh will provide good results, but it's my feeling that amphora mesh will allow for shorter columns since it's packed more evenly giving better vapor – reflux contact. Ceramic materials and pieces of glass are far less efficient than scrubbers, but may be used if there are no other choices. In that case taller and wider column is a good idea.

Column material, I did my first experiments with white polypropylene pipe that I attached with soldering iron to the lid of a fermentation bucket. This didn't work very well. First of all the bucket lid and the pipe I used were somewhat different compounds and didn't stick too well causing leaks. After prolonged testing (well over 100 hours of operation) the PP pipe had deformed from the lower part, and provided slight off smell/taste. There are different brands of PP with different temperature tolerances, so you might find a brand that suits the task (I've heard good things about black PP pipes used for irrigation and such).

After that experience I switched to copper and made a column for my real still that incorporates the spiral. The thing is that I attached the heater to the column, so that I can insert the heater through 40mm hole into the boiler and regulate the power via dimmer switch as usual while keeping my 25L SS stockpot intact. It required slight violence to deform the heater with vice grips in order to fit inside a 40mm pipe, so I'd recommend 2 inch pipe if readily available.

The spiral in my case is not as tightly wound and has inner and outer spiral for stability reasons. A regular spiral as FP shows can be used as well. I'd recommend 10mm pipe for efficiency reasons though. Also 5 meters cannot handle 300W, so if you want to run at full power and good insulation longer spiral is a good idea.

Working with copper plumbing components is thoroughly explained in books from Nixon, McCaw and Smiley + online information can be found at http://www.moonshine-still.com/ so I won't go into that.

I used reducers 40mm-25mm + 25mm-15mm + piece of 12mm pipe to attach the spiral to the top of the column. Have the 10mm or 12mm pipe protrude into the column to have the reflux drip in the middle of the packing. A separate liquid distributor may be used (perforated plate for example), but I won't guarantee it makes any difference. Pure tin is strongly recommended for soldering, available at most hardware stores.

The other end, well there are plenty of ways to attach the column to the lid, do the search and find the one that suits your case (Tony's site www.homedistiller.org is a good place to start searching). For copper column on the plastic lid approach I'd recommend permanent joint as easiest approach. Say 20cm x 20cm copper plate soldered to the column as a flange. A column going ~2cm through the lid which is glued in place with aquarium grade silicone. SS bolts, nuts and washers on the edges of the plate to secure the attachment. Bead of silicone in the inside seam of the bucket and the lid. Just one way to do it if you are having trouble figuring it out.

Boiler, fermentation bucket can be used off course. If you have regular still it's boiler can be used as well if the heater is attached to the column.

Connecting the heater, in my case I didn't want to cut my boiler so I attached the heater to the column. As there will be hot ethanol dripping from the column I added two pieces of 5mm copper pipe to cover the electric wires. They are semi permanent, go through holes in the side of the column and are hold in place with hose clamp. Whole thing is sealed with plenty of aquarium grade silicone.

At the lower end of pipes there are short sections of PVC pipe connecting to the heater (these will be mostly submerged during operation). Note if possible use some silicone hose, it tolerates alcohol much better.

Operating procedures

The reason I really like this still is that it suits very well for a lazy persons like me. With power controller you can make it shut down between heads, main run and tails. You can start it in the evening, let it equilibrate over night, slowly collect the heads during next day (while you are at work for example) and start the main run next evening. With predetermined power levels it will close or slow down considerably when main run is finished. All you need to do is start it, adjust power few times and change collecting vessel few times. This all takes place over a period of few days so you don't need to hurry. As a bonus it keeps my garage warm during the run.

Starting the still

Starting is just as usual, assemble and fire her up at full power. It's a good idea to measure the alcohol content in your mash and calculate the boiling point (I usually use one of the calculators at Tony's site). This way you can use a thermometer with alarm to tell you when to adjust down the power (set the alarm 1-2 degrees lower than the boiling point). When boiling is reached adjust the power so that the upwards part of the spiral is warm while downwards is cool. This means you operate in full reflux. Let your rig to equilibrate for some time (I usually leave it overnight).

Heads

After this is finished crank up the power slightly to have roughly 10-20cm of the downward pipe warm. Let it drip until it ceases or the ethyl acetate smell is gone. Toss the first .5 dl, the rest is heads you can redistill later. You should collect from 2dl-5dl depending on your mash and other variables. The output should be very slow now or even ceased. Crank up the power slightly and test if the product tastes and smells like pure ethanol. If the product is not yet pure crank the power up only slightly from previous setting and continue slow collection until satisfied with the quality. For

flavored spirits you might take some of the late heads phase into the final product, depends on your taste.

Ethanol run

When pure ethanol is coming out, adjust the power to have 30-60cm down spiral warm. This means 1 drop every second or two seconds at 95+% neutral spirits. At this stage you usually make ~1-2 liters in 24 hours. I usually collect the stuff twice a day to ensure I won't accidentally go into tails in case I'm a bit clumsy with power settings. When the main run is finishing the output again slows down or ceases. Some traces of 1-propanol might find it's way into the last few dls. If that happens the product makes pretty good white rum for drinks.

Tails

Now you can collect the tails with both cranking up the power slightly and doing a slow collection, or upping it more and doing a quick collect. There's not much ethanol left in the mash, so unless you are after whiskey or rum you may very well finish the run now. Turn off the power, remove insulation and let it cool down.

Tips

The dimmer type power controllers usually have a turn wheel that's not permanently fixed to the shaft. Remove the wheel, saw a slot to the shaft and attach your own pointer to get precise control of power levels. It's a good idea to mark your power levels for different stages to be able to duplicate the run.

If you have trouble storing the thing you can use a 10mm compression coupling and some Teflon tape to make the spiral removable.

That’s about it. I suppose enough material has been written about drinking the stuff so I don’t need to go into that. The good thing about ethanol made with this type of procedure and equipment is that it won’t produce many hangovers. I don’t take any responsibility though ;) For questions, at times I can be reached at http://groups.yahoo.com/group/Distillers or at abbababbaccc@yahoo.com

Greetz, Riku