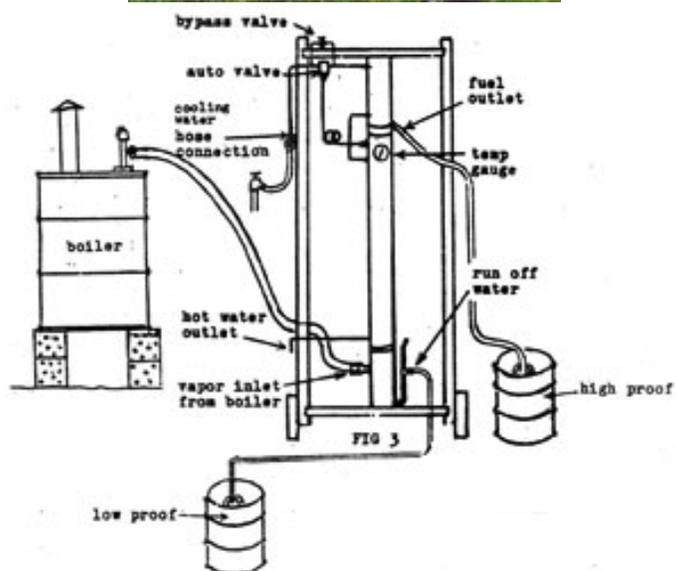
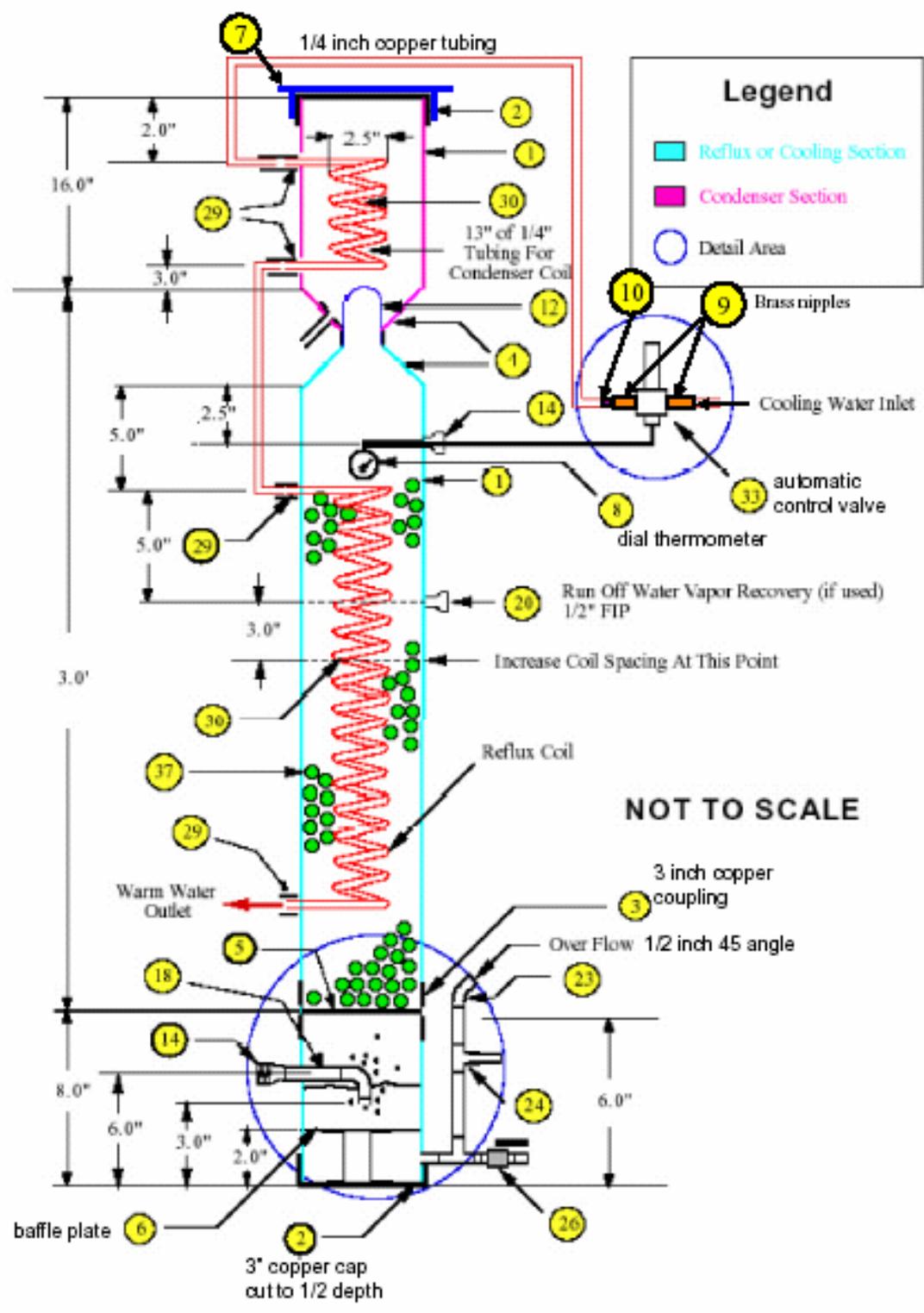


# Building an Ethanol Still & Making your own Fuel

by Robert Warren



The Charles 803 model still.



When in doubt about this drawing, refer to the blueprint. It is more precise. Text describes variations in drawings.

## Part 1: Cutting and assembling the pieces

In the course of building this same still design many times, and teaching others how to build this still, I have devised several shortcuts, which will provide you with easier and faster ways to complete this task. That said, speed is not everything. You are now about to build a tool, a fine piece of technology which will provide you with the means to put fuel in your car, regardless of whatever is going on in the oil fields or the board rooms of oil barons.

The cutting of the pieces, the assembly and soldering is not a difficult process, and you will very likely enjoy your accomplishments as the day unfolds. The most important thing is that you understand my instructions before you do any cutting or soldering. Once a pipe is cut too short, it cannot be made longer, only shorter again. I don't want you to waste any materials, plus it may delay you a whole day by having to go out and buy a replacement for something that was done wrong. So I have inserted photographs wherever possible to fully explain what needs to be done. Most of the photographs are of my still and me, but I have just added a few better ones, close-up, done by Floyd Bates. He shined up his copper fittings real nice, and you can see he took pride in his work.

If you have never done any soldering before, I take you through the process when the time comes, so you can learn while you build. An experienced plumber/welder can build the entire still in a single day, but this project may take you a whole month of weekends, if you are new to this stuff. I recommend you have a friend join you in this project. It is a lot easier and more fun that way. You should have everything you will need ahead of time, without having to make an extra trip to the hardware store. My web page, [“Principals of Operation”](#) provides the explanation of each of the different sections, and what functions they perform.

I recommend that you tack the still blueprint to a wall adjacent to where you will be working. As you make your measurements and put it together, this will not only keep the plans clean and readable for future reference, but also you will need to refer to it many, many times during the day to make sure that you have everything right.

This first chapter deals only with the distillation column itself, and the next chapter deals with how to build a boiler, and various types of heating schemes. The distillation column, as described previously, is where the separation of the alcohol and water vapors take place, and the condensed water exits out the bottom right, while the distilled alcohol drains out the 1/2” diameter tube placed at a 45° at the bottom of the alcohol condenser section.

You may find it difficult to find 3” ID Type M copper pipe or 3” copper fittings, as hardware stores do not carry this. You need to find a plumbing wholesale supply house to buy this. They sometimes label it DWV pipe, but it is copper, not plastic, like most DWV pipe. Type L is thick walled and more expensive, but it will work fine, it is just more expensive and harder to cut. You may find that they have 3” copper pipe, but will not cut it, as a wholesale supply warehouse normally only sells uncut pieces. You don't want 20 feet of 3” pipe, as this is very expensive, so you might try to call a plumber who does fire sprinkler jobs—they use this stuff all the time, and he may have some left over. If you can't get it at the wholesale place, try a commercial plumber, who may have a leftover piece.

Email me if you have problems locating the automatic valve and thermometer.

Dimensions on the blueprints at detail one are full sized, in inches, not metric. I apologize to my international friends for the fact that the USA has not adopted the metric standard. Since I am not

familiar with metric sizes of plumbing fittings, you will have to simply use your rule or tape measure against the drawing itself at detail 1 to get your dimensions, and use the approximate metric equivalents. Please note that the actual full height of the still is 64 inches (dimensions are shown at the far left). The middle section, the reflux column, is 36" long, with an architectural zigzag on detail 1, just opposite the 3/4" female fitting, just a little below the fuel outlet. This zigzag represents a continuation of a line, without drawing the entire set of plans 64" high.

There are two variations of the basic design shown on the blueprint, but **we are only going to discuss and then proceed with the variation shown in the top center of the blueprint page, labeled "alternate method"**. This is such a superior design in actual performance, plus it is much easier to construct, that we will not bother with the combined coupling and funnel assembly shown in detail one of the blueprints. The problem with the earliest design, shown in figure one and detail one, was that too much heat is transferred along the wall of the 3" copper pipe through the coupling above the reflux section, making it difficult to keep the condensed alcohol from re-boiling. Furthermore, permanent attachment of a piece of insulation material in the lower cone area is difficult to do, and even more difficult to know if it remains attached. If it detaches during use of the still, you cannot see it or do anything about it. By changing over to building the alternate method, which we did fairly early in the course of teaching our workshops, we found that not only is there a greater difference of temperature between the top two sections, it also is so much easier to construct. It even provides an easy lifting point when you need to move the still. I mention this right from the outset, as this slightly changes the list of materials on the blueprints. In the materials list above, we do include the two reducing couplings. So use this materials list, rather than the ones on the blueprint.

The other exception that I will mention is the type of packing material inside the reflux column. We have always used glass marbles, as they are relatively cheap, and not as heavy or expensive as other materials. If you had a fairly clean source of marble sized rocks, such as from a riverbank, this will work as well as the glass marbles. You would have to sort out all the smaller ones, however, as they should all be roughly the same size so that you have plenty of air space for the vapors to rise up through the column. Plus, you will have to wash and then wash them again, to flush out smaller particles of dirt. Smaller pebbles, sand, and dirt mixed with larger ones may tend to work their way down to the bottom area and form a packed area, clogging up and completely shutting off the flow of the steam.

Hence, it is so much faster and cleaner to use glass marbles, as they will be uniformly sized, and the glass does not react with the vapors, and does not corrode. I looked around a long time to buy marbles the last time I build a still, in the summer of 1999, and found only one real source, as toy stores don't even seem to have them anymore. Go to a store which sells plants and home decorations, as there are many types of glass marbles and large glass oval beads which are made in Mexico, and are used for putting inside a clear glass vase for holding flowers. These are fine.

There is yet one other commercially available material superior to marbles, which is to buy the actual alcohol reflux ceramic packing rings, which is what a commercial refinery would use. This is something you are not likely to find unless you know someone who works at a big distillation factory. They are called Raschig rings. The ceramic rings have better thermal properties (they are slower to change temperature) than marbles, but unless you are going into commercial production of large volumes or fuel, you will not see any difference in performance between commercial ceramic reflux packing and ordinary glass marbles. I have a commercial source for these Raschig/Raschid/Raschi rings. If you go to [http://www.home-distillation.com/culumn\\_filling.asp](http://www.home-distillation.com/culumn_filling.asp) then give the user name "**extra**" and password "**bra**". (don't ask!) This site has lots of info about various column fillings including Raschig rings, part of the Gert Strand empire (selling yeast, hydrometers, etc.

One more thing, in terms of learning the terminology that plumbers use for fittings. MIP represents male iron pipe (standard thread size) and FIP represents female iron pipe threaded fittings. Also, Americans take it for granted that you understand that an apostrophe (') represents one foot, while a quotation mark(") represents inches. ID means inside diameter, OD is outside diameter.

*Please read* through the first few pages of these instructions before you shop for materials. The photos will help you understand what these items are and how they fit.  
(item numbers in blue correspond to numbers on drawing, page 2)

## BILL OF MATERIALS FOR CHARLES 803 STILL

Red is quantity, blue is units, etc. Cu means copper (chemistry notation on periodic table)

### Item Qty Unit Description Comments

1. 5 ft 3" ID pipe Cu (either type M –better- or type L: thick walled, harder to cut)
2. 2 ea 3" end caps Cu bottom cap is cut down to shorter size (see instructions)
3. 1 ea 3" couplings Cu
4. 2 ea 3" x 1.5" reducer coupling Cu (If they only have 3 x 2 reducers, get this instead)
5. 1 ea 3" OD brass or SS shower drain plate (Or, you can make this, explained step 8b.)
6. 1 ea 2-3/4" diameter solid plate, Cu (do not buy-- make this per step 8)
7. 2 ea 4" white PVC toilet floor-flange To attach the still to your frame
8. 1 ea 2" dial thermometer with 1/2 " MIP thread Temp range 50° to 220°
9. 2 ea 2" long x 3/8" MIP brass nipple For attaching to automatic valve
10. 1 ea 2" long x 1/4" MIP brass nipple For attaching to water line
11. 3 ft x 1.5" ID PVC Schedule 40 plastic pipe For making coils
12. 1 ft x 1.5" ID Cu pipe (type M) For joining reflux & condenser columns (or 2" per item 4)
- 12a. 3 inches 1/4 inch tubing flattened with hammer and bent into U shape, made from item 30.
13. 1 ea 3/4" to 1/2" reducer brass fittings
14. 1 ea 3/4" FIP female adapter Cu
15. 2 ea 3/4" MIP x 3/4" male hose thread, This will screw into a 3/4" copper adapter
16. 1 ea 3/4" x 3/8" brass reducing bushing
17. 1 ea 3/4" elbow, 90° sweat Cu
18. 1 ft 3/4" copper pipe, (type M)
19. 6 ft 3/4" Drain hose Dishwasher or washer drain hose
20. 3 ea 1/2" FIP adapter
21. 1 ea 1/2" elbow 90° Cu Sweat fitting
22. 2 ea 1/2" brass plugs for plugging drain & Runoff vapor recovery fitting
23. 1 ea 1/2" 45° Elbow Sweat fitting
24. 2 ea 1/2" tee Sweat fitting
25. 1 ft 1/2" copper pipe, (type M)
26. 1 ea 1/2" brass ball valve for still drain
27. 1 ea 3/8" x 1/4" brass bushing
28. 1 ea 1/4" needle valve, brass 1/4" ferrule fittings both ends. For manual bypass of automatic valve.
29. 4 ea 1/4" couplings Cu for 1/4"OD tubing (solder type) For heat exchange coils
30. 50 ft 1/4" OD soft copper tubing Refrigeration tubing. DO NOT buy type L (hard copper) copper water tubing!
31. 2 ea 1/4" brass tee fitting for 1/4"OD tubing Ferrule type
32. 1 ea 1/4" MIP x 1/4" compression adapter for 1/4"OD tubing Brass
33. 1 ea Automatic temperature control valve. Opens on temp rise at 171°F. Penn V-41-AA
34. 10 ft Clear plastic hose Polyvinyl, 5/8" I.D. (inside diameter)
35. 1 ea lead-free plumber's solder Tin/ Zinc (no lead) Not electrical solder (not rosin core).

- 36. 1 ea 4 oz. solder paste Plumbers flux (and a small flux application brush)
  - 37. 700 ea Glass marbles, or glass beads from a florist shop
  - 38. 4 ea Brillo pads NOT steel or plastic, just SS or copper
  - 39. 1 roll Teflon tape 3/4" wide, or TFE plumber's paste
  - 40. 4 ea Hose gaskets For drain hose if gaskets do not come with them
  - 41. 3 ea SS hose clamp 3/4" to 5/8" range
- Cu = copper; OD = outside diameter; ID = inside diameter; FIP = female iron pipe;  
 SS = stainless steel; MIP = male iron pipe; ea = each; ft = feet; in = inches

## TOOL LIST FOR CHARLES 803 STILL

### Item # Qty Unit Description Comments

- 1 1 each MAPP gas cylinder Burns hotter than propane, for 3" fittings
- 2 1 each Propane cylinder For small soldering joints , 1/2". 3/4", etc.
- 4 1 each Flux brush
- 5 1 each Pliers Slip joint type
- 6 1 each Pliers Needle nose with long nose
- 7 2 each Channel locks Bigger the better, you have to grip a 3" pipe!
- 8 1 each Plumbers sandpaper (or steel wool) very fine grained (not coarse)
- 9 1 each Plumbers torch (I prefer the trigger type, self-igniting)
- 10 1 each Torch lighter/striker
- 11 1 pair Gloves Leather is essential, you are working with a torch
- 12 1 each Hacksaw or, Sawzall with metal cutting blade (24 teeth to the inch)
- 13 2 each Hacksaw blades (24 tooth per inch)
- 14 1 each 8" Half-round file half round on one side, flat, double cut on opposite side
- 15 1 each small Round file 3/8" diameter
- 16 1 each Rubber mallet (you can use an ordinary hammer with a block of wood instead)
- 17 1 each Tin snips
- 18 1 each Pipe wrench 14"
- 19 1 each Tape measure 10 foot minimum
- 20 1 each Drill 3/8" chuck or larger
- 21 2 each Drill bit 1/8" (.125) For metal
- 22 1 each Drill bit 1/4" (.25) For metal
- 23 1 each Drill bit 3/8" (.375) For metal
- 24 1 each Drill bit 5/8" (.625) For metal
- 25 1 each Drill bit 7/8" (.875) Metal hole-cutting type with pilot bit.
- 26 1 each Vice grips
- 27 1 each Table vice or pipe vice for cutting of large 3" pipe
- 28 1 each Tubing cutter, plumber type One inch is OK
- 29 1 each Pencil #2 or lumber pencil Or magic marker
- 30 1 each Center punch
- 31 1 each Bucket of water Fill with COLD water
- 32 1 each Mason jar lid as template for baffle plates
- 33 4 each Rags Cotton is best
- 34 1 each Metal coat hanger for grabbing the coils

## Getting Started

1. Before you do any soldering on your expensive 3 inch copper pipe, practice a bit on some smaller stuff first. My instructions start out with the 3 inch pipe, but if this is your first time, skip down to trying, say, Step number 5, as the smaller pipe joint in that step will be inside the still, and so it won't matter much if that one, if you are a "solder virgin", look bad. Download and print the following set of instructions from the Copper Tubing Handbook, for an excellent set of soldering instructions, with photos.

<http://www.copper.org/tube/dbk/soldered-joints.html>

2. Cut the 5-foot section of 3" copper pipe into three sections, according to the dimensions in figure one. You will need one section 8" long, one 36" long, and then your final piece will be 16". If you are cutting with a hacksaw, start with a new blade that is designed for cutting metals. If you do not have a pipe vice, a regular vice can hold the 3" copper pipe solidly, but you will need to pad where the vice clamps the pipe with some cloth so that you do not nick the copper with vice marks. If you do not have a vice or a pipe vice, I recommend making a miter box out of wood 2 x 4's. Just take a straight 2" x 4", say, 2 feet long, and attach a couple of 1" x 4" pieces to both sides, so you have a channel in which to hold the pipe you are cutting or drilling. You may even temporarily attach this to your workbench for great stability.

As you cut your 5-foot section of pipe into three sections, each cut needs to be absolutely straight, or you will end up with one side longer than the other. Take your time with the saw and watch that it cuts straight. If you do end up with one side being 1/4" or 1/2" longer, this is still workable. You may have to tighten your hacksaw blade so it clamps the blade tighter. Try to do better on your next cut.

2. File all six ends of your three pieces of pipe. You should use your flat file (I prefer a half-round file, flat side) to remove all burrs from the ends of the pipe working from the outside in, and you may use your half-round side of the file to work at removing burrs which are hanging onto the inside ends of the pipe. Finally, use the flat file to smooth the ends of the pipes, filing perpendicular to the length of the pipe, so that you don't end up with a shape knife-blade from too much filing. You will be handling these pieces a lot, today, and you don't want them so sharp that you get cut while working on this.

### Bubbler section

3. Take one of the end caps, and put it partially on the end of the 3" pipe, which is only 8" long. You should just gently tap it on so that it is only on your pipe about an inch of the cap not making contact with the 8" long section of pipe. You are going to cut off most of the side wall of the cap, so that you only have 3/4" or 5/8" of side wall left on this cap. By putting the cap partially onto the 8" section of pipe, you are giving yourself something to grip with while you cut it with the hacksaw. Remember how you had to cut straight with your first cuts? Well, there it didn't matter as much if you went a little bit off at an angle, but here it really does matter. This side-wall has to be cut off absolutely straight, or else you may find yourself

with no side-wall whatsoever on one side, and then when you go to attach it to the end of the pipe, there is no outside surface of the cap to solder to on one side.. If that happens, throw that end cap away and try it again.

Grip the 3" cap in your vice, or with really big pump pliers, and start your cut exactly 3/4" from the end of the cap. You are going to remove 1-1/4" from the cap. Measure and mark with a pencil where the end of the cap will sit on the 8 inch pipe so you can see when you cut through the cap, you are not cutting into your 8 x 3" inch pipe. When you are done, clean up the end cap with your file, and you may need to tap off the copper ring if it is stuck on the outside of your 8" section of pipe. Use the back part of the jaw of the channel-lock pliers, and tap along the length of pipe, towards the end, to remove the cut-off piece of ring material. You will have to tap just a little first on one side, then the other side, because it has to come off straight or it will not come off at all. You may set this ring aside, it is now scrap, and will not be used.

This photo shows the end cap cut down to the minimal height, baffle plate attached.



4. Take your 8" section of pipe, and mark and center-punch a spot exactly 6" from one end. You are going to drill a 7/8 inch hole. This is the bubbler section, where the 3/4" female adapter will be attached to the 3/4" copper pipe which will be inserted through this hole. You will find this a little easier if you first drill a 1/8" hole at your center-punch mark, and then when you change to the larger bit size, the drill will not drift off, and will stay centered in the right spot. You will need to clamp this pipe while drilling, as you need to keep it from moving, and you don't want it to whip around in circles when the drill bit decides to "bite", instead of cutting. As you drill through the side of the pipe, you must be careful not to wobble your drill, as you do not want to make this hole any bigger than the 3/4" pipe, which will be inserted here. Use your round file to clean up the hole you have drilled, and use the end of your 3/4" copper pipe to check for perfect roundness and fit. This pipe should fit this hole exactly, without a hairline of air space anywhere around the hole. In fact, it should be so

tight that you need to tap your 3/4" pipe into place when you are ready to insert it, which you will do a few steps further down.

If you do not have a 7/8" drill bit, (because you may find that this size requires a 1/2" drive drill, rather than a 1/4" or 3/8" drive drill.), then you can mark your 3" pipe with a pencil, using the outside of a piece of 3/4" pipe to make your circle, centering it on the center-punch mark you made. You have to make a circle, not an oval, on the side wall of the 3" pipe (when you hold the end of the 3/4" pipe up to the outside of the 3" pipe, at a right angle, it only touches the smaller pipe in two points. You have to scribe a circle on the side-wall of the 3" pipe which is exactly round, the same size as the 3/4" pipe. One way to mark this is to use your tubing cutter to cut off a very short piece of 3/4" pipe, only 1/2" long, and then you can use this very short piece as a template, which allows you to hold a flat lumber pencil against it to scribe your circle. Then, once you are satisfied that your circle looks like a circle and not an oval, and you double-check the size of the circle against your 3/4" template piece, you may center-punch a series of marks just inside this circle. The outside edge of the holes you drill should fall exactly on your penciled circle mark. You are going to drill a series of 1/8" holes close enough together around the circle until you can tap and punch out the entire piece, leaving a series of jagged edges which will have to be filed with your round file so you end up with just one hole perfectly fitted for the 3/4". This is a lot slower than using a 7/8" bit, but if carefully done, provides a better result, as sometimes a 7/8" bit can get out of control and gouge your work, causing serious damage. You will also spend a lot more time filing to get your hole to match the 3/4" pipe which gets inserted.

This shows the bottom (left item) as it will look like when finished.



The assembly on the right is the mid-section joint, steps 25 & 26.

**5.** Now you are going to make up the downward pointed 90° elbow and drill it full of holes. First, cut two pieces of your 3/4" pipe at 1-5/8" length, exactly. Use a pipe cutter to get a good, clean and square cut. Use your emery cloth or plumber's abrasive cloth to thoroughly clean and polish both ends of these pieces of pipe. Solder doesn't work unless the pipe is completely clean. Spread some plumber's flux on one end of each pipe. Inset the fluxed ends of these two pieces of 1-5/8" pipe into each end of your 3/4" copper 90° elbow. Now, apply flux paste to one of the short pieces of 3/4" copper pipe now attached to the elbow, and slide on the 3/4" x 1/2" reducing adapter. Now, hold this assembled piece with your channel lock pliers, and solder it together. If you need instructions on soldering, please read my notes on soldering at the end of this chapter, or get someone to help you who has soldered before. It is properly soldered when you can see that the solder sucked into the joint, all the way around the fitting, without leaving any voids. Drop the hot joint, after soldering, into a bucket of water, so you may quickly cool it and go on to the next step.

**6.** Drill a pattern of holes in this elbow, as well as in the small end of the reducer coupling you have just soldered, exactly as shown in the pattern on the plans. These are one-eighth inch holes. Please note that you also need to draw a 1/8" hole just exactly at the top corner of the elbow, and this is also shown on the plans. When finished drilling, file off the burrs, then grip this piece in your vice, or else hold it solid with your channel locks, and using your hacksaw, cut four sets of paired notches, 1/4" deep, at the bottom of the 1/2" reduced end of the reducer. Use your needle nose pliers to bend four tabs out as shown in detail one, labeled "slotted ears".

**7.** Make the baffle plate assembly as follows: Cut a piece of 3/4" pipe 2-1/2" long. Cut four tab notches in one end of the pipe as you did with the smaller end of the 3/4 x 1/2" reducer in step 6, above. Your tabs only need to be 1/4" long, but they must all be the same depth. Now cut identical tabs at the other end of this pipe. Bend these tabs out like you did before, and flatten the tabs with your pliers so they all are flat and in the same plane. You want to stand this up on end in the center of the 3" end cap, which has had the side-wall cut away (step 3, above). File and polish this, apply flux, and solder it to the center of the 3" cap.

**8.** You need to make a baffle plate that will sit on the top of the stand you just made. Using your tubing cutter, cut a 2-5/8" long piece off of the 1-1/2" copper pipe. Using your hacksaw, and slit it lengthwise. You will have to hold this in a vice in order to make this very difficult cut. Now, with your pliers, open it up so it is almost flat. Place it on a wood block, and take your hammer, and pound it until it is completely flat. Use a Mason jar lid as a compass, and mark a 2-3/4" circle in the exact center of your flat piece of copper. You need to cut off the excess rectangular ends with the tin snips, so that you end up with a circular flat piece of copper, which will fit inside the 3" diameter bubbler section. It won't be exactly round, it will have two sides that are clipped, because your original piece of pipe was only 2-5/8" long. When you look at detail-1 in the plans for the baffle plate, it says you want 1/16" clearance all the way around. This is too hard to get exact, and it seems to work a bit better by having a little more room on both sides of the slightly oval-circle you end up with. Now, you need to drill 6 or 8 holes, 1/8" size, in a

rough circle, or even in a random pattern in this flat plate. File off the edges and any loose burrs.

**8b.** Now if you couldn't find a 3 inch diameter shower plate for the separator which is item number 5, you can make this out of the 1-1/2 inch pipe the same way you just made your baffle plate. Cut a piece of 1-1/2 inch pipe exactly 3 inches long. Then cut this short piece length-wise and use your big channel locks to open it up into a flat piece. Flatten it out with your hammer and/or your vice, and use the scrap piece from the 3 inch cap to draw a 3 inch circle on this flattened copper. Cut it into a circle and then drill lots of 1/8 and also quarter-inch holes. You have to be more careful cutting this one, as it should just fit exactly inside the center of the 3 inch coupling, and you don't want it to fall inside the 3 inch pipe. File the edges until it fits exactly.

**9.** Now, the baffle plate needs to be soldered to the stand. The drilled holes have burrs on one side, so if you put the burrs faced up, you have a smooth surface where it attaches to the support stand tabs. This plate needs to be perfectly centered on the stand, so look straight down on it and line it up with the inside walls of the cut-off bottom cap. Remember, you are going to have to fit the cap onto this 8" length of pipe, and this baffle plate must not be too far off-center, as otherwise the cap cannot properly fit over the end of the pipe. If it is off center, forcing the cap on the pipe may put a strain on the soldered baffle stand, and it may come apart internally. You may want to line it up first, then turn it upside down to mark it with a pencil, or even to grasp one of the tabs with vice grips or channel locks, and hold it in place while you solder it. Be sure to use plenty of flux each time you solder, and don't get it too hot (it is too hot if the copper changes color). Be sure to solder where the end of the pipe stand touches the plate, as well as soldering the tabs. Drop this in a bucket of water to cool it.

**10.** At 180° opposite the 7/8" hole you made in the 8" section of 3" pipe, at the bottom end, mark a spot just 7/8" up from the end of the pipe. Center-punch this mark and drill a 5/8" hole here. Be very careful that your drill does not drift off your center-punch mark, so first drill a 1/8" hole at this mark, so this hole will keep your 5/8" drill bit centered. If you don't take this extra precaution, you may have a hole which cuts through the end of the pipe, instead of leaving a 1/2" margin below the hole. This is where you will insert a very short piece of 1/2" pipe, for the condensed water run-off. File the burrs and make sure you have a press-fit tightness with the 1/2" pipe which inserts here.

**11.** Cut a piece of your 1/2" pipe at 7/8" long. Make two tabs on one end, 180° apart. Fit this through the hole of the 5/8" hole you just made in the 8" section of 3" pipe, above, from the inside out. You need to squeeze the tabs against the inside surface of the 3" pipe, so you make good contact so you can solder these contact points for additional support. Apply plenty of flux and solder this so that the 1/2" length of pipe sticks out straight without being angled up or down. You need to be very spare with your solder, because if you goop up this joint with too much extra solder, then you will not be able to fit the bottom cap over this end of your 8" section of pipe. The best place to solder this joint is on the inside of the 3" pipe, as you have easy access to this joint, as it is located right at the very end of the pipe. Before you solder, however, it is also a good idea to fit the bottom cap against this end of the 8" pipe and make sure that everything fits together

before you solder this 1/2" pipe stub. You may need to use your round file and file a bit of a dip in one edge of the bottom cap, just to allow for the roundness of the pipe at that one particular spot.

**12.** Take a five or ten minute break. Relax. It doesn't have to look pretty, but you will nevertheless be quite proud of your still when you are done, if you polish it as you go. I like to clean it up after soldering each joint, as it polishes better when still a little hot and there is still a light film of flux on the copper. You can use a cotton rag, but it is best to use some very fine steel wool, and it polishes it to a nice shine. This also prevents green goo spots from appearing on the copper later on.

**13.** Before you can assemble the cap to the end of the bubbler, you must first assemble the 3/4" FIP to the 3/4" elbow with all the holes drilled in. First, use your round file to contour the fitting end of the 3/4" FIP adapter so that it matches the outside wall of the 3" pipe. Sand all the surfaces of the fittings, then push the 3/4" stub which has the elbow with the holes in it, from the inside of the 3" pipe through the 7/8" hole so that it sticks out straight. Be sure the elbow with the attached reducer points downwards, towards the 5/8" hole at the lower end of this 3" pipe.

Apply flux, attach the 3/4" FIP adapter onto the 3/4" stub, and line up the contoured edges of the adapter so that you have a very tight, close fit where the solder adheres to easily, forming a good strong joint. You need to apply solder from the inside, as well. You can see this joint looking through the end of the pipe, and if you straighten out a long piece of solder, it will get sucked around the entire joint if you heat this pipe stub evenly, just where it sticks through the 3" pipe. If you first solder the outside FIP adapter to the 3/4" stub, as well as to the 3" pipe itself, you won't need to add much more (if any) heat to apply the solder on the inside of this joint. Drop this whole assembly in a bucket of water to cool. Pull it out of the water once it is cool to the touch, wipe away any excess flux with a rag, and inspect for pin-hole leaks. If you find any areas that did not get properly tinned (soldered), then apply more flux and re-solder as necessary.

**14.** Now you are ready to assemble the bubbler. First, you need to sand the inside wall of the bottom end cap (which is only 1/2" high, remember?) Then, before you attach the cap to the 8" section of pipe, you need to pack 4 copper "Brillo" pads around the baffle stand. These pads must not be detergent-impregnated, as some of the pot-scrubbers are. These are just normal, plain copper pot-scrubbers. Remove any plastic, and if you see a small steel staple holding the Brillo pad into a ball, remove this, as well (it would just rust). Sand both ends of the 8" length of pipe with emery cloth, so you have it shiny clean. Apply flux, and fit the cap over the bottom end of the 8" section of 3" pipe, lining up the rounded notch or dip you had to file in the last step. Solder this together. You have to use a lot more heat to solder a 3" diameter pipe than you do with smaller pipe, as there is so much more copper material to conduct the heat away from the joint. Keep your solder handy so that you keep touching the tip of solder to the joint and get the solder to start flowing just as soon as it is hot enough, not waiting until it is too hot. (if it is too hot, the solder beads up and falls off like water droplets). Keep rotating the pipe so you get the solder all the way into the joint. The solder gets sucked into the joint if you are at the lower end of the solder's melting point temperature range, and when you see the solder

getting sucked into the joint, you know you are doing it correctly. Drop into the water bucket, then inspect and re-flux and re-solder if necessary.

**15.** Next, you need to attach the 1/2" elbow to the 1/2" pipe stub for the run-off water. You do have an option here. Instead of soldering an elbow, you should solder a tee with the middle tee opening pointing straight up. Solder the 1/2" elbow on the 1/2" pipe stub so it is pointing straight up, as shown in detail one. Do not attach the 1/2" pipe and tee fitting just yet, as it gets in the way when you are soldering the bubbler section to the reflux section.

### **Condenser section:**

**16.** Drill two 1/4" holes at locations shown near the top of Figure one, in the 16" long piece of 3" pipe. One hole shall be two inches from one end, and the other shall be 3" from the opposite end. Both holes should be lined up so that one is exactly above the other when stood on end. File off the burrs carefully, and check the size of the hole with the end of the 1/4" refrigeration tubing. This hole should be just slightly looser than the last two side holes you drilled. The reason for this is that you are going to make an internal cooling coil with the 1/4" tubing, and you will have to insert the end of this tubing thorough the 3" pipe from the inside out.

**17. Make your condenser section.** This is really a two-person job. This will be perhaps the most difficult part of this whole construction, but it really helps if the holes you just drilled are just big enough for the tubing to pass through this hole without restriction. But, at the same time, this must not be so large that you end up with a gap on one side of the tubing where it sticks through the sidewall. It will also help if you closely follow the instructions for unwinding and then tightly winding the coil, so that you end up with uniformly spaced coils, and absolutely no kinks, as a kink would cut down on the water flow, which must be able to flow fully through un-kinked tubing. First, unwind 7 feet from your 50" coil of tubing, cut it, and set it aside. This will be used later for making your water connections. When you unroll the tubing, remove the coil completely from the cardboard case, and unroll the tubing from the outside of the roll, rotating the roll of tubing while another person holds one end of the tubing and walks away from you, backing up in a straight line (If you unroll the tubing from the inside of the roll, it will have an unwanted twist which makes for difficulty later on). So, whenever you cut the tubing, use a tubing cutter, not a hacksaw, as this needs to be a very clean cut. A hacksaw will likely distort the end of the tubing, and it needs to be perfectly round to fit through the holes you drill.

**18.** Next, you need to support your three-foot long section of 1-1/2 inch plastic pipe so that it is solidly attached to a pipe vice. Be sure you use schedule 40 PVC or ABS

type pipe, as this has a thick enough wall that you have just under 2 inches outside diameter (actually, 1-7.8 inches OD).

If you do not have a pipe vice, you may use a 1/16<sup>th</sup> drill bit to drill two holes in it, one which is only 3/4" from the end, and another which is 12" inches from that same end. One technique is to hammer this pipe down to your workbench. Another technique is to hold it with your foot on a step as I am doing in the photo below. If you choose your workbench, use two 16-penny nails (common, not box nails), or, two 3"- long metal screws, nail or screw this pipe to your work bench so that you have about 23 inches overhanging the end of your workbench. Place the pipe on one end of your workbench (or overhanging a wooden deck or the side of a stair-step), and start the nail through the first hole you drilled. Start the nail or screw through the hole and then hit it with your hammer so it pierces the other side and goes deep into the wood. A 16 penny nail is a little over 2-1/2" long, so it should go into the wood solidly. It is OK if you smash the nails a bit deeper, the only thing is you will want to remove the pipe from your bench later on. You will need to be able to work directly in front of the overhanging pipe, while you wrap the tubing around this bending jig. There good photos of this on pages 17 & 18.

#### **19.**

Now, with two people (one to hold the 50 foot coil of copper tubing, and unwind it straight off the end as described above, and the other to wrap the tubing around the 1-1/2" pipe you have secured to your vice, workbench or deck), measure off two inches from the end, and at this point, start by wrapping one end of tubing around the secured piece of 1-1/2" pipe. This will take a bit of strength and effort to keep the tubing bends very tight around the 1-1/2" pipe you are using for a bending jig. You must be very careful not to flatten this tubing as you coil it. The key is to move the tubing only an inch at a time, and squeeze it into a tight bend with your bare or gloved hands. If you try to bend longer sections, you may kink or flatten it. There is no tool I know of which makes this any easier. As you first get two or three wraps around your pipe-bending jig (the 1-1/2" pipe), you will have to use one hand to work the coil around the pipe, while the other hand alternately feeds and squeezes the tubing into a coil.

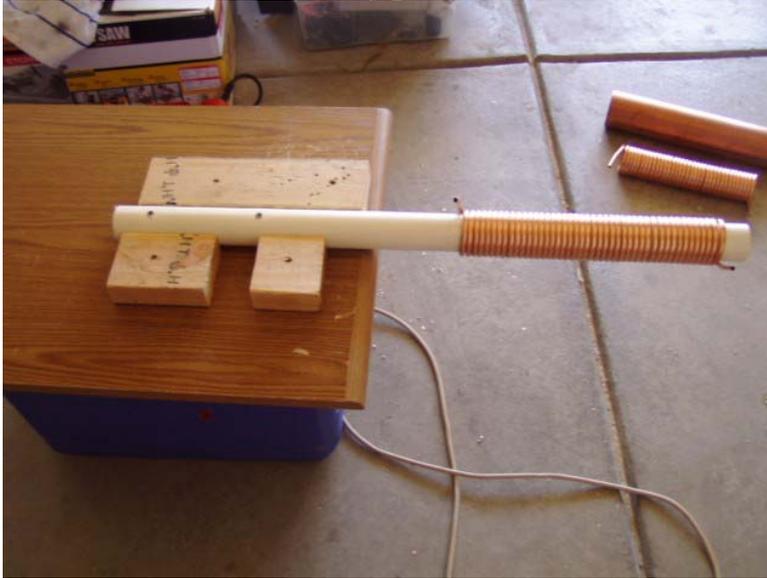


Here in the above photo, I am standing on the 1-1/2" pipe I am using as a rolling jig, and have it pinched up against the back step of my house, to hold it securely. With my left hand (the hand in front, wearing a leather glove), I am twisting the coil away from me, while the right hand guides the straightened-out copper tubing onto the newly-formed coil.

One technique which works is to turn the tight coil wrapped around the pipe away from you, and hold on to the unwound section of tubing only about 4" away from the pipe, with the straight part angled upwards towards your head. Then, pull the straight tubing in your hand (which is only 4" away from the pipe) down and towards the bending jig. If you have a third person to help at this point, it is helpful to have this person hold the edge of the channel-lock pliers jaw in between the first and second wraps of tubing, and to work with you as you twist the tubing around while feeding more tubing to be coiled. The pliers are not there to grip or pull, but only to rest against the outside of the 1-1/2" pipe as a spacer between the coils, so they aren't touching. This person is not essential, but sometimes it doesn't hurt to have an extra set of hands helping with this task. It is easier to make your coils even now than it is to try to space them properly later on.

Proceed slowly and carefully, and stop and re-consider how this looks, as this is a very important step and must be done correctly. Look at the coiled condenser tubing at the top of Figure one, as well as the details in Detail 1 (I am referring to the hardcopy of the still blueprints which you will get in the mail). But, forget about Detail 2 in the center of the page, for the moment. Your goal is to make 13" of evenly spaced coiled tubing with about 2 or 2-1/2" sticking out straight at both ends. One other point, before you cut off the 2" long straight piece out the end. You want both ends to be pointed the same direction. This is very important. One end will curve around clockwise (if you hold the tubing vertically) and the other end will curve around counter-clock-wise. They should both be able to point the same direction, as the two holes you drilled in the 3" pipe are vertically lined up. Then you cut off the remaining tubing that is still in the larger part of

the recently unpackaged roll of tubing. If you do this correctly, you will use about 14 or 15 feet of tubing, and have about 28 feet of tubing left on the coil. If you kink this coil, you may as well throw away this section and start over with a new box of tubing. You will need full water flow through this tubing for a high production rate, so again, proceed slowly and carefully while you are winding this tubing into a tight coil. If you wind it too tight around the 1-1/2" pipe, this is better than being too loose, as you can always untwist it a bit in the end to release it from its grip on the larger pipe. Also, you can pull both ends out a little like stretching a spring, but like a spring, you cannot push it together if you have stretched it too much. Do not remove it from your pipe jig quite yet, though. Here it is on the workbench jig.



**This photo shows a finished coil.**



I am holding it on the end and looking to see if I have both ends coming out pointing the same direction so I can insert the ends through the holes drilled in the side of the middle reflux section.

Here is another photo showing tight windings near the top of the reflux section, more spacing nearer the bottom end.



**20. Inserting the cooling tubing.** Now you need to unwind just a little of each end of this coil, and then pull on the very last coil so that you are pulling the straight end of the

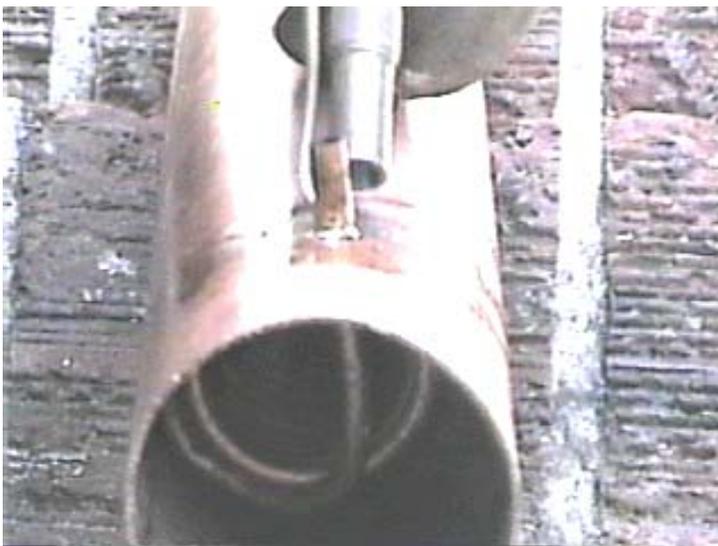
coil to be even with the outside straight line of coil. Now is the time to look at Detail 2 and see how this should look. This looks easy, but to get it just right takes a bit of attention to detail, and perhaps a bit of luck. Exactly one-half way around the first coil, you need to unwind it just a bit by pulling it back away from the end of the tubing, and downwards so you have a wide “last wrap” which drops down even with the next to last coil. Do the same on both ends, but do not put any unnecessary kinks or bends in this coil. All you are trying to do is to pull the straight ends back just enough so that the entire coil fits inside the 18”-long piece of 3”pipe.

Remove the coil from your pipe jig. It is springy, and if it holds onto the pipe too tight, just work it off slowly by untwisting it slightly and temporarily.

Go ahead and insert this piece of springy coil inside the pipe. Turn both ends towards the drilled holes, and try to line them up. If they come even close to lining up, then fashion a hook on the end of the wire coat-hanger in the list of tools, and use it to hook the coil and pull it up straight so it gets forced out the drilled 1/4”hole. (You did try to see that the ends of your tubing will slip through these holes, didn’t you?) Now your holes will be about 11 inches apart, so you may need to compress the spring just a little. If you get both ends lined up but cannot quite pull them through, you may try threading a small sheet metal screw into the end of the tubing by threading it lightly into the end of the tubing, through the drilled 1/4”holes as you see in Detail-2. Also, read the notes with Detail two.

If you can get the end of the tubing started through the hole, and the screw feels like it bites into the tubing (without distorting or flaring it outwards), then give the screw another half-turn, and you can grab on the head of this screw with your vice grips, and pull the end through the hole. However, at the same time, your friend must help by pulling up the curved last coil of tubing with the coat hanger, as in Detail 2. If the screw won’t bite, try a different sized screw. Or, you may be better off not to try the screw, as unless you are very careful, you will flare out the end of the tubing and it will be too big to fit through the hole, or the coupling you have to solder on later. So, work at it with the coat hanger a bit longer before resorting to the screw.

**Top of coil inside the condenser section.**



Look closely at the dark area inside the pipe in the above photo, and you can see the coil with the end coming out to the outside. I am soldering this to seal it.

**21.** Once you get one piece of tubing through the hole, just enough so that you have 3/4-inch of tubing sticking out, polish it with your emery cloth, apply flux, and solder on a 1/4" coupling. This will keep it from disappearing back into the pipe while you work at getting the other end to come stick out like the first one. You need to have only enough tubing sticking out to fit into the coupling, and you need to pull any excess back inside the still column. You have to solder the base of the 1/4" coupling to the side of the 3" pipe, exactly where it protrudes. This is stronger than soldering around just the tubing itself. Then use your coat hanger (and sheet metal screw, if necessary) and pull the other end of the tubing out the other hole and solder it, as just described. Next, use your coat hanger to pull the last half-loop of coil on the inside of the pipe up so that it touches the pipe wall opposite to the hole where it protrudes. You may need to push against the coil to keep it in place while you apply flux and solder the first and last coils of the tubing to an attachment point just opposite the protruding end, as shown in Detail Two. This coil, especially the bottom end of it, and where you solder it, should look just like the detail at the top of Detail one, where it says. "Solder to brace".

**22.** Using the remaining amount of tubing, unwind it and wrap it around the 1-1/2" nailed down or vice-clamped piece of pipe, just as you did with the condenser section. You will again start and finish with a 2"-long piece of straight tubing, and again they should both be pointing the same direction when you finish the coils. You are wrapping the coils fairly tight, as before, and when you are halfway finished, you will have part of your coil dropping off the end of the fixed 1-1/2" pipe jig. This is OK, just make sure it doesn't get stretched out too much as it falls free, out of the way. Use up the entire amount of tubing. Space your coils evenly, as before, and again, take your time with this coil, as you cannot allow any kinks or flattening in this section, either.



Top of condenser section with coil inserted.

**23.** Once you have made your second, longer cooling coil, set this aside for now. You may remove the 1-1/2" pipe from your workbench, and cut off a 7"-long piece off the end which has no nail holes in it. This will be the pipe which joins the condenser to the reflux column, as shown in the Alternate method, near the top center of the plans.

**24.** Clamp one of the 3"x 1-1/2" reducing couplings very firmly in the vice. Using your round file, you need to remove the internal "stop ring" from the inside of the smaller end of the 3"x 1-1/2" reducing coupling. This will allow you to insert the 7" long piece of pipe inside this fitting so that the top end of the 7" pipe is even with the top end of the 3" fitting. You may apply flux to the pipe to get it to slide in and out easier, trying from the top rather than from the bottom to see if you have removed enough material for a complete insert. But, do not insert this pipe just yet.

**25. Assembling the fuel outlet.** You also need to drill a 5/8" diameter hole on the bottom sloping side of the same reducing coupling which you were filing on the inside in step 24. This is a difficult hole to drill, as your bit will want to slide on the curved surface of the fitting. You need to center-punch this hole exactly 7/8" up from the point where the smaller side wall joins with the angled side-wall. Use a piece of 1/2" pipe as a visual guide to see just where the pipe needs to fit so that when inserted through this hole you are about to drill, and hold it up to the drawing in the alternate method detail, so you understand exactly how it should look. You may drill from the outside in, or from the inside out, whichever is easier for you. Proceed with drilling the 5/8" diameter hole. Next, cut off a 4" length of 1/2" pipe, polish one end with emery cloth, then cut two pairs of opposite notches 1/4" deep like you are making two more tabs, as you did earlier. File off the burrs, then insert this pipe through the 5/8" hole you just drilled, and position so you can bend the tabs down into place so they will lie flat against the inside of the 3" reducer. Finish any filing you may need to do to get the 7" piece of pipe inserted into place, this time from the bottom (and applying lots of flux so it slides easily, and get ready to solder both insert pieces of pipe by heating it just one time with your torch. Then insert the 7" length of 1-1/2" pipe into this coupling, sliding it well past the filed-out stop ring, and even with the top of the reducer coupling. Look at the alternate method drawing to see that you have proper positioning. The smaller end of the fitting should be heated first, however, so you may apply the solder from the top and inside of the fitting. It is easier to assemble this joint if you have it in the same vertical position as it appears in the drawing on the set of plans. Use plenty of flux, but be sparing with the solder, again remembering to keep touching the solder to the fitting as you heat it so that it starts to pull into the fitting before it gets too hot. You will likely have to use vice grips or have your friend hold the 4" length of 1/2" pipe into place so that you get a good attachment of the inside tabs to the sloping side-wall of the reducer fitting. If it gets too hot, step back and let it cool for a minute, and then start in again. Or, use your pliers to pick up the whole assembly, and drop it into the bucket of water, then take it out, inspect it for where it still needs to be soldered, and apply more flux and go back to soldering. When you are done, you should be able to remove it from the water bucket, and as you lift it out, hold your thumb over the lower end of the 1/2" pipe and see if the upper section of the reducer holds water. This is your fuel outlet, where your finished high proof alcohol comes out.

You have to make sure that you have no voids in the soldering, and no extra solder on the inside walls of this coupling.



Preparing the midsection joint

### **Midsection with fuel outlet:**

**26** There is one last thing that you must do with this fuel outlet assembly. The top of the 1-1/2" pipe, the end which is even with the top of the 3" end of the reducer coupling, must have something attached to it to keep the marbles from running up into the condenser section whenever the still is laid on its side. Take a piece of 3/4" pipe, and cut two very short rings off it, each only 1/4" wide. Then cut the two rings open with your pliers or tin snips, and fold them out a bit, so each one makes a half-circle. Fit one of these half-circles just inside the top end of the 1-1/2" pipe, the end which is even with the 3" end of the reducer coupling. Hold it against the inside of the pipe with vice grips (remember to use flux) and solder one side. Then, attach the other side of this little narrow strap to the other side of the inside of the 1-1/2" pipe and solder. You can see this detail in Figure one, near the top, where it says to attach this to the outside. It may be inside or outside, but I have found that placing it inside provides a little bit tighter fit that prevents marbles from getting between sections. Attach the other little copper strap so that it crosses the first one, and it may be inside or outside the 1-1/2" transition section. Solder it, and after it cools, use a marble to see it fits through any of the four ports you just created at the top of this transition section. No marbles should get through here.



On the top of this smaller 1-1/2 inch pipe which you see in this photo is where you will attach a couple curved strips of copper to keep the marbles from the bottom section from rolling into the top section if you lay the still down into a horizontal position for carrying it. The smaller 1/2 inch pipe on the lower right of this photo is the high-proof fuel outlet.

27. You may now shine up the lower end of the condenser section (the lower end has the tubing sticking out at 3" up from the lower end), and also polish the inside of the reducer coupling assembly you made in the last step. Apply flux and fit the 3" end of the reducer coupling onto the 3" pipe, being careful that the high proof spigot you just made (the 4" piece of 1/2" pipe) is exactly opposite the two stubbed out ends of 1/4" tubing. Tap it lightly into place with a hammer, if it needs a bit of persuasion, but remember, this fitting has to go on straight and evenly, as it will bind up if it gets even a little cocked over to one side. If you are not sure if you have the fitting all the way on the pipe, you may measure with your tape measure. The top section is 16" long. The reducer fitting depth may be measured against the remaining reducer fitting which you have not yet used, and you can calculate how far into the fitting the pipe is. Tap it lightly with a block of wood paced over the end of the 3" pipe, if you need to coax it in further. Solder the condenser to the reducer/drain assembly, and you are now for the moment done with the condenser section.

Set the condenser aside for now, as the top cap doesn't go on yet, as it is the last thing you solder into place.



This is the condenser section being soldered into place, after gently tapping it inside the 3-inch midsection joint. Read on further, as it doesn't get attached yet.

## Reflux Section

**28.** Now you need to drill another 7/8" hole, as you did before in step 4, at a point just 2" down from the top of the 36" long reflux section. Center punch it, and drill carefully, holding the pipe in the vice or the pipe miter box you made out of your 2" x 4".

**29.** Next, just one inch lower and 90 degrees away from the 7/8" hole you just drilled, you need to mark and drill a 5/8" hole. File the burrs off of both holes, and use pieces of 3/4" and 1/2" pipe to be sure you have exactly the tight press-fit you will need, just as was necessary with the two holes you drilled in the bubbler section, earlier.

**30.** Now, just two inches lower than the 5/8" hole you just drilled, and in a direct line with the first 7/8" hole, drill a 1/4" hole for the tubing to fit through. This hole will be 5" from the top of the reflux column, as you may see on your set of plans. On the other end, in a direct line with the top 14" hole, but just 3" up from the lower end, you may mark and drill the last 1/4" hole in the pipe. File this with your round file, and test these last two holes with the end of the 1/4" tubing, again to see that it fits easily (but not too easily) through these holes, as now you have a longer piece of coiled tubing to insert. (but do not insert it yet.)



**31. (optional)** You have one last hole to drill in the reflux section, but you may never use it. Therefore, this step is optional, and you may skip it if you think you will never want to modify the still for future expansion. Otherwise, this is the only since you have to drill this hole, and it could come in handy later on. This will be a 5/8" hole, exactly opposite the 7/8" hole at the top of the reflux column (and therefore also exactly opposite the two 1/4" holes for the cooling tubing). This hole will be 10" down from the top of the reflux column. It will get a very short piece of 1/2" tubing, just 3/4" long, inserted into this hole, but not before it is attached to a 1/2" FIP adapter. First, using your round file, contour the fitting end of the

1'2" FIP adapter so that it matches the curvature of the 3" diameter pipe. Then insert the very short, 3/4" long piece of 1/2" pipe into the FIP adapter, solder it, then cool it in the bucket. Now you may insert this fitting and pipe stub into the 5/8" hole, apply flux and solder it into place. When cooled, wrap a 1/2" brass plug with some Teflon tape, and screw into this fitting. Remember to hold onto the outside of the fitting with a pair of channel lock pliers as you tighten the plug, as you do not want to break your solder joint by twisting it off.

**32.** Insert the cooling coil. This is the same technique as before, only this time, the holes are further from the ends of the pipe, so this might be just a little harder, but perhaps you will find it easier, as you will know what worked for you on the first section.

**33.** Once you have fished the 1/4" tubing out of those little holes, you need to very carefully see that the 1/4" couplings still fit these tubing ends. File them lightly, if you need to, and polish them with emery cloth. If you have to try to squeeze them back into a round shape if one of the ends is oval shaped, then do it ever so carefully, or you are more likely to just end up smashing it in the opposite direction. If it is wedged out due to the screw you were pulling on it with, try to file it down. If all else fails, to get a clean tubing end suitable for soldering into the precise fit of the 1/4" coupling, then try to pull out a little bit and cut it off with the tubing cutter. You don't really have much straight tubing to pull on, but if you have to, rather than pulling on the tubing, try to use a long screwdriver or your coat-hanger to pry out more of the tubing so you can cut off the ovaled or smashed part. Pull the tubing back inside afterwards.

**34.** Solder couplings on to the tubing ends. Each of the four tubing ends should have a 1/4" coupling on it, so here you are soldering on the couplings just as you did in step # 26. These do have to be soldered couplings, as compression couplings will wear down eventually. Caution: you are going to re-solder these same couplings later on when you have to install the tubing hookups that go to each coupling. With this in mind, do not use too much solder, as an extra drop inside the solder coupling may prevent you from getting a new piece of tubing into the coupling. The other thing to be aware of is that the coil may want to spring back and disappear inside the 3" tubing if it has any spring tension on it due to having had to pull on it in order to pull the end out straight. This is possibly the worst thing to have happen, and it has happened, after the couplings were soldered on and it was no longer possible to manipulate the coil. So, this is one of the reasons for insisting that you solder the opposite side of the very first coil wrap against the opposing wall from where the coil end protrudes. This is shown on the plans at the top of Detail 1. The second reason for attaching the coil to the wall of the column is that this reduces stress on the joint where the coil comes out through the 1/4" hole, as the coil does flex as it goes through its temperature changes during the heating and cool-down periods. Plus, remember to solder the base of the 1/4" couplings to the wall of the still.

**35.** Next, you need to solder on the 1/2" and 3/4" FIP adapters (female threaded adapters). First, contour the ends of the fittings to conform to the outside diameter of the 3" pipe, as you did earlier. For the 3/4" fitting, you must cut a short stub of 3/4" pipe 1-1/8" long and create two opposing tabs, 1/4" deep as you did earlier. If you can first insert the short stub through the 7/8" hole, then using a long screwdriver reaching in from the end of the 3" pipe, bend these against the inside wall by tapping them down with the screwdriver and hammer. Next, make a

short 7/8" long piece of 1/2" pipe for the smaller fitting, and insert it into the 5/8" hole. Make sure you have a snug fit, and that they stick out exactly straight, then polish and apply flux, and slip on the 3/4" FIP adapter, as well as the contoured 1/2" adapter. The tabs need to be soldered from the inside of the pipe, but you may heat the 3" pipe from the outside and solder both the pipe stubs to the outside wall of the 3" pipe in just one application with the torch. Be sure to get the solder to pull up inside the FIP adapters, as they must be fixed solid, as with every other appendage on this still. While the pipe is still warm, wipe off the excess flux drippings with a rag (and notice how it shines up the copper.)

**36. Attaching the bubbler.** Now you need to fit the 3" diameter shower drain plate inside a 3" diameter coupling, and after polishing and applying flux, slip it on the bottom end of the 36" long reflux column. The thin steel plate will hold the marbles from dropping down into the bubbler section. The bottom end of the reflux section is of course the end without the fittings attached. Next, you may polish and flux the top of the bubbler section, and attach it to the bottom end of the coupling you just slipped on. Note the alignment of the holes. You should have the tubing ends, as well as the 3/4" adaptor on the bubbler section, all lined up and on the left side, as shown in the detail drawing. Solder both ends of this coupling. You may have to turn the still upside down as well as to rotate it to get the solder to flow completely into the coupling, all the way around. All soldering must be done just as if it were going to hold water under high pressure, as it is actually going to have to contain steam at high temperature, which is every bit as critical in terms of being necessary to be leak-free. Cool and wipe off.

Now it is time to fill the reflux column with the marbles. You have the still standing upright, with the bubbler section attached at the bottom. Fill with marbles one bag at a time, letting them roll both inside and outside the coils. Try to fill a little on the outside first, then some on the inside, then some on the outside, letting them settle into place. You may have to shake the still a bit so they can get down near the bottom. Keep filling until they reach to the top loop of coil. Plug the FIP fittings with a piece of rag so you don't lose any marbles.



This photo is attaching the bubbler (lower section). The condenser isn't attached yet.

### 37. Attaching the condenser.

Polish the end of the reflux column, and the insides of the remaining 3"x 1-1/2" coupling. Apply flux, and attach the condenser-section with the 1-1/2" pipe joining the finished condenser section to the reflux section. Note that all 1/4" tubing ends should be lined up with each other. Solder the coupling to the pipe, again, turning the whole thing upside down if you have to get proper access with the flame and solder to get it to flow inside the fittings.



38. Next, you may solder the top cap in place.

39. You are almost done. Cut 3 pieces of 1/2" tubing to the dimensions shown at the bottom of detail 1, and attach to the tee and couplings. Solder these into place. You have to make one more very short 1/2" stub, only 1-1/8" long, and solder it into the end of the bottom tee with a 1/2" FIP adapter as shown in the penciled-in revision.

40. Measure a piece of 1/4" tubing to reach from the bottom cooling coil of the condenser section and to go straight down about a foot and then to make a wide (not sharp) bend and cut it where it will attach to the other 1/4" cooling tubing at the top of the reflux section. You can see how these two cooling sections interconnect in Figure 1, where the arrows on this section of tubing shows the direction of flow. Flux and solder it into place.

41. Clean off the still with your rag. Build a stand for the still, similar to what you see in Figure 3. If you make the frame a bit shorter than 5 feet, then you can use the 3" wide pipe clamp to attach it to the top bar of the still.

42. Use Teflon tape or TFE paste on the brass nipple threads, and attach a 3/4" male hose adapter to the bottom 3/4" FIP. The temperature gauge (and thermo-well) screws into the 1/2" FIP fitting in the upper middle of the still. The remaining hose and water fittings will be described in the next chapter, along with how to construct the boiler.

The frame is a simple wood construction. Here I used a couple of white plastic 4 inch toilet floor flanges which I used as a socket to receive the two ends of the 3 inch copper pipe caps. At the bottom I cut out a notch for the 1/2-inch drain fitting assembly. The water inlet connections haven't been made up yet, but this is shown in the drawing in the Pdf file.



Here, I used a PVC toilet floor flange to secure the top and bottom ends of the still to the frame. The white thing in front, middle, is a white plastic plug I installed temporarily to close the hole where the temperature gauge will be installed (and keep the marbles inside).

**Congratulations! You have just made yourself a fine piece of distillation equipment!**

## Boiler instructions

Murphy's Law says that if anything can go wrong, it will. In terms of running a still, this means you must pay attention, and follow the following safety warnings, so that you make a still which will not blow up in your face.

Alcohol as a liquid is not dangerous (unless taken internally) but ALCOHOL IN A VAPOR CAN EXPLODE! It would be useless as a fuel if this were not true. That said, petrol (gasoline) is far more dangerous, and yet we use it every day, except generally, not around open fire.

This still is really a lot safer than most batch stills.... A: because the boiler can be set up at a distance from the still. And.....

B: because it operates for all practical reasons, pretty much at atmospheric pressure. no internal pressure is allowed to build up. This part is detailed in the next section, on building the boiler.

A pot still is far more dangerous with the reflux column up there on top of the boiler, where the spillage and vapors are directly above open flame or an electrical heating element.

Alcohol does not explode like gasoline. Gas vapors go off with a bang. Alcohol burns more slowly, so when it lights, it goes off with more of a whoosh which may ignite something else. So just keep flammable stuff at a distance.

This still is very small. Don't let the size fool you. It can produce as little as a quart an hour, or it can get up to several gallons an hour. This is because it operates on vapors from a boiler containing fermented brew. The distilling process actually begins at the boiler. The boiler can be anything from a small pressure cooker to a 1000 gallon boiler.

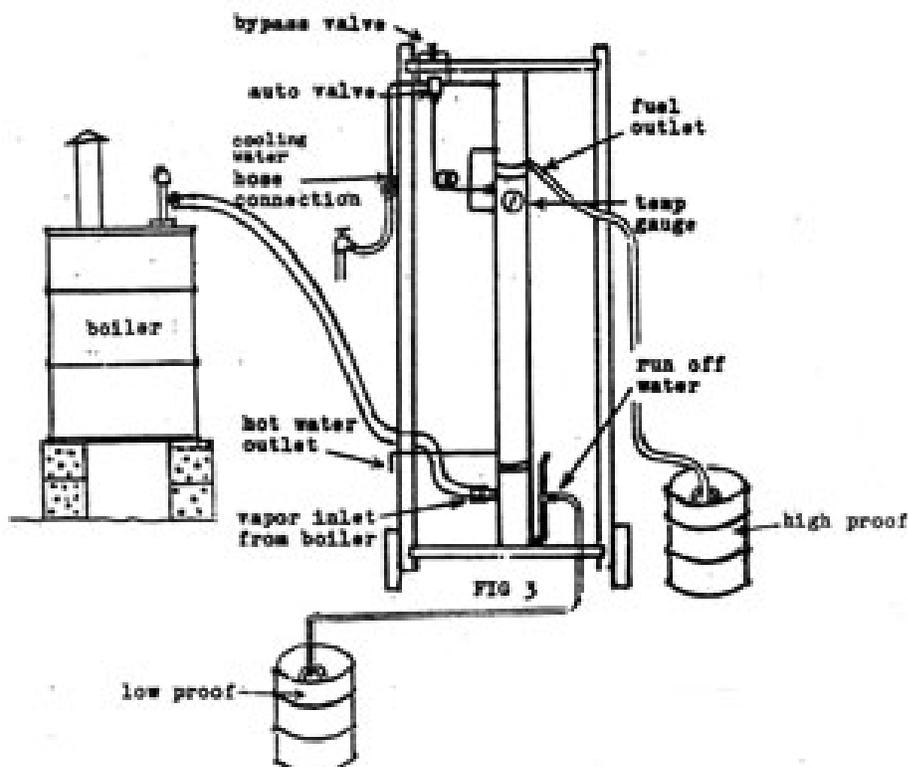
Distilling is a process by which the alcohol is driven out of the beer by heat. When two liquids are mixed, their boiling point changes to a point between the boiling points of the two liquids. Just where this new boiling point is in terms of exact degrees depends on the concentration of the two components of the liquid.

Vapors mixed together act independently.

Because we are starting with a solution containing less than 15% alcohol, a great deal of water will be vaporized as we heat the liquid.

This drawing shows the boiler as a 50-gallon drum standing on end on concrete blocks. This is easy to set up, but is not ideal. It is far better to lay the barrel on its side, as this allows for faster and more efficient heating as the flames warm more of the barrel's surface. This requires driving stakes next to the outside of the blocks so they don't roll outwards due to the weight of the barrel.

Also, the safety release valve is shown at the top of the barrel. This valve is set for releasing steam if it gets above 2 psi. Text at the end tells you how to make one.



The boiler should present the largest liquid surface area possible. Vapor comes out of the liquid only at the surface, so the more surface area, the greater the opportunity for the vapor to leave.

If you are using a 50-gallon oil drum (I like to find a used vegetable oil drum, as there is no smell of petroleum), use it in a horizontal support rather than in a vertical position. This way, there is also more area on which to apply the heat, making a more efficient use of your heat source. For example, with a 200-liter oil drum. If heat is applied to the end of the drum while it stands vertically, the vaporizing surface would be the diameter of the drum. If the drum were lying on its side, the heated surface and the vaporizing surface would be considerably greater. The boiler should be vapor and liquid tight and able to withstand heat and pressure.

The distilling process begins at the boiler and the plumbing from the boiler to the still becomes the first stage of the still. If the piping from the boiler is not insulated, much of the water will condense and run back into the boiler or out through the runoff outlet at the bottom of the column. A slight downward slant from the boiler to the column will prevent the water from draining back to the boiler. This simple plumbing trick will extend the capacity of the still greatly.

**REMEMBER:** All the still is doing is cleaning the water out of the vapors before condensing them. The higher the proof we want, the more cleaning we want. As soon as the vapors come out of the boiler, any slight cooling will strip out a portion of the vapors.

**WARNING:** Just as a covered pot will boil over when cooking rice or pasta, this can be a much bigger danger when heating such a big container. The main thing is, never have a completely closed container. While we don't want an open vent like the little hole on many cook-pot lids, as this would release lots of precious alcohol, we do want to blow off steam if it gets above 2 or 3 pounds pressure.

**Build your own safety vent:**

The cheap and easy way to do this is to put a tin can upside down over a pipe fitting at the highest point of the barrel, with a 1 kg. rock to hold it down. But you will probably lose a bit of steam, and therefore, precious alcohol this way. I use a 2-inch tee fitting with a 2" pipe nipple screwed into the top of the cooker barrel. Then, screwed into the side of the tee, a pipe nipple with a reducer bushing sized to the hose adaptor fitting which feeds the hot steam down through a 5 foot long black radiator hose to the 3/4 inch fitting at the bottom of the distillation column. On the top side of this 2 inch tee is a brass reducer bushing which is whatever size I can find to fit a steel ball bearing. It is always a bit of luck to come up with a nice steel ball bearing about 3/4 inch in diameter, but once you find one, take it to your local hardware store and see what you can find in the way of brass reducer bushings or copper fittings, as you want it to form a good seal. So you end up with this steel ball sitting at the very top of your cooker pot, and if the steam pressure gets too high, say above 2 pounds per square inch, this ball will start to dance around a little and relieve the excess pressure before it becomes dangerous. This is safer than buying a steam release valve which is probably set too high to be safe. In the drawing to the left, you can see the safety valve just above where the hose comes off the barrel.

## DOUBLER

The doubler is the bottom section of the drawing and where the vapors first come into the still. Here we create a pool of liquid from the stripping above and make the incoming vapors pass through it. This does several things.

1. The vapor heats the pool. In heating the pool the vapor will be cooled and a considerable amount of the water will condense. The reason it is called a doubler is because it was found that just about half the water condenses out every time it passes through one of these pools.
2. The heated pool will be above the boiling point of alcohol so that any alcohol falling from above will be reheated and go back up.
3. This pool will keep any solids that might have reached this point in suspension so that they will flow out in the runoff. This is a very important part of the still, even though it isn't difficult to build. In order to keep the pressure that is built up as the vapor passes through the marbles from forcing the pool out, the pool should be at least seven inches deep. The depth of the pool is set by the trap made by the runoff line.

## MARBLE STRIPPER

Most stills will have a vapor stripper section, which may be plates or marbles. The Charles 803 Still combines the two types. There is a plate at the bottom and one at the top of this section with many holes in them. These holes should be at least 3/16 inches in diameter so that the liquid going down will not close the holes and stop the vapors from going up. They should be small enough that the stripper material does not fall through. The plate at the bottom supports the stripper material and the top one distributes the downward flow more evenly.

The first vapors entering the bottom of the still at the doubler will encounter the cooling pool, condensing some of the alcohol, lowering the boiling point of the pool. A 5/8" pipe runs through the stripping material from above the vapor inlet to below the stripper coil inlet to allow some of the vapors to rise and cool quickly and replenish the pool before the boiling point is lowered to below the temperature of the incoming vapors, causing the pool to boil out.

You have just learned the principle behind the big steam columns.

They supply steam at the bottom of the column and beer at the top. The plates inside work just like the marbles and the up and down flow begins. This type of still uses live steam to heat up the stripper, which also boils the beer. Either by controlling the amount of steam entering or the rate the beer is pumped into the column the proof is set. Because heat must be transferred from heat source to water to brew, and because the steam column adds water vapor which must then be condensed, steam columns are large and not very heat efficient.



This is the Heineken Brewery in Amsterdam—a great place to visit! They use 4 different types of kettles: I have an explanation of their process on my website, [http://running\\_on\\_alcohol.tripod.com/](http://running_on_alcohol.tripod.com/)

## CONTROL SECTION

This section simply puts a distance between the top of the stripper coil and the condenser to keep the two from affecting each other, and allows us to get some idea of what is happening inside the still. We need some reference temperature so that we can set the proof of the alcohol coming from the condenser.

The middle of the control section will give us a reference temperature. Let us stop for a minute and see what this reference temperature tells us. First we know that pure alcohol at sea level will boil at 173 degrees F. We don't want the temperature at our reference point below this or we will be condensing much of the alcohol. In order to distill a high proof alcohol the temperature should be as low as possible. The automatic valve will control this accurately. Exact temperature depends on altitude and a variety of other factors. The flow of water in the condenser coil needs to be no greater than sufficient to cool the liquid to 100 degrees F. This flow will be determined by the amount of vapor to be condensed and the amount of water in those vapors, which is determined by the temperature of the vapor going in. The flow of water through the stripper will be determined by the proof we want. The more vapor going through the still, the more water needs to flow through the stripper to keep the temperature of this section constant. The water going into the stripper should be the water coming out of the condenser. This water is already warmed somewhat, so it is less likely to over-strip or condense alcohol vapor. The water should enter at the top and come out the bottom of the stripper coils. The water coming out the stripper will be at very high temperatures. It can be used as a heat source for the distilling room, another room or part of the alcohol production process.

## THE STILL IN OPERATION.

The first thing to be taken care of, long before you hook the still up to your boiler, is to see if you have any liquid or vapor leaks from the still. Vapor loss means loss of alcohol. This can be checked before operation by sealing off all but one opening in the still. Blow air into that opening. Any air leak would be a potential vapor leak. Seal these up. Once you get started and the mash is boiling, you will see steam leaking out if you have a leak.

If you install a second thermometer (similar to the one in the reflux column) in the liquid area of the boiler, you can watch the temperature rise in the boiler. The only way to do this cheaply is to get a thermometer which has a long, flexible temperature probe which could be inserted through a sealed, threaded gland with a packing gland to seal the vapors. It is handy but not all that necessary, and I have done fine over many years without one. It is far better to have the temperature gauge mounted on the still, as shown in the blueprints.

At some temperature just above 173 degrees F, the pipe between the boiler and the still will begin to heat up. The exact temperature at which this happens will depend on the concentration of alcohol in the brew. A low boiling point indicates a high concentration of alcohol. You can follow the vapors by feeling the pipe and still as they warm up.

Remember - The still starts at the boiler and the vapors are being cleaned as they travel. This is perhaps a good place to explain why I prefer marbles in the distillation column instead of pot scrubbers, as used by many home whiskey distillers. We are going to be boiling a lot of different types of mash mixes over the life of this still, and some things that boil contain large amounts of floating organic particles, which get stuck inside the small voids inside the pot scrubbers, and eventually clog it up. Marbles, on the other hand, being made out of smooth glass, can easily be washed off between every few distillation runs, by connecting a garden hose to the  $\frac{3}{4}$  inch steam fitting at the bottom and washing the still internally with a high flow of water.

O.K., the mash is starting to boil, so soon the temperature in the control section will start to rise. When this occurs, start a cooling flow of water. If you are controlling the water flow manually, let the temperature rise to around 190 degrees F and hold it there for only a minute or so, to start with. Turn the water flow up a bit until you see the still thermometer drop to about 175. This still responds to adjustments in the water flow almost immediately. But without the automatic temperature control valve, you have to fiddle with the temperature every minute or two, and every time the temperature gets too high, the more water gets up into the condenser, and the lower your proof. We don't need to be concerned about using a hydrometer to measure the proof at the early stages of production, as the hot, high proof alcohol will make the hydrometer reads falsely due to temperature. It is just more important early on to try to stabilize the water flow so the temperature remains constant at 173 F.

Once it has leveled off, start more water flowing through the coils. The less vapor flowing through the still, the smaller the change and the slower the reaction should be. Be sure you allow time for the change to take place and the proof to level off.

If you have an automatic valve, you won't know at first what temperature it is set to. So first, you have to figure out which way to turn it to adjust the temperature. So you need to figure this out before the mash starts boiling. Start by turning it fully one way, then the other, while your mash is heating but not yet boiling. Turning it all the way to the lowest temperature setting will open the valve and you will see and hear water flowing. Turn it all the way the other way and the water will stop, long before you get to the end set point. For now, leave it at this setting. Then, when you start to hear the mash start to boil, turn it a little bit towards the cooler setting, and you will start to see the cooling water flow. Turn it a bit more, and watch the temperature gauge on the still. Again, you will see this temperature react immediately, as they are both sensing the space internal temperature zone. Adjust the cooling water flow by turning the small screw which increases or decreases spring tension on the control valve. Your water valve will be all the way open, as you need to let the automatic valve do the temperature control, as it is a lot faster than you are. Try to get it exactly at 173F.

When the control section temperature stabilizes, you will see alcohol begin to come out.

**Check your boiler, as you may need to turn down the heat**, just like you would when you are cooking rice or pasta, and it starts to boil over. This is important, as you are boiling with a closed cooking pot, and if it really starts to boil over, you not only have a mess, you might get

scalded by steam! This is why it is better to use a gas burner for your first couple of times of running the still, as a wood boiler is much harder to control.

Let the still stabilize here and check the proof, raise the temperature slightly, stabilize and check the proof and so on until you reach the highest temperature your valve will allow, or the lowest proof you wish to distill. Once you are familiar with the valve, you may set it quickly to get whatever proof you like and it will consistently get that proof.

Don't be surprised if the alcohol starts coming out before you turn the water on. This is because the marbles are cooling the vapors at the beginning. The vapors also condense on the condenser coils as they warm the condenser.

**REMEMBER:**

You are not applying heat in the still. The control temperature is the result of vapor flowing from the boiler. If you don't have any vapor flow, the temperature will not be very high. The more alcohol in the beer, the sooner the vapor begins to flow. If nothing but water ever comes out of the still, there was no alcohol in the brew. This is why you need a balling hydrometer; to figure out how much alcohol you have in your beer/mash. Soon after you start distilling, there will be some flow out of the runoff outlet. This will mean that the pool in the doubler section is full and the still is nearly stabilized. Once the pool is full and you have adjusted the temperature to the proof you want, alcohol flow will increase. The up and down flow is established and the pool is flashing the alcohol that reached it back up to the stripper. As long as the heat is being applied to the boiler at an even rate, the vapor is removing all the heat that is being put in.

**REMEMBER:** The brew (as you boil it) is losing alcohol. The smaller the batch or the more heat being applied, the faster this happens.

As the alcohol percentage falls, the temperature in the boiler will begin to rise. This is because the boiling point of the mixture is approaching that of water. The rise in temperature will be seen in the still also, so little by little more water will have to be sent through the stripper to hold that temperature steady.

Watch the boiler temperature closely (look and listen, if you don't have a temperature gauge here) and record these temperatures and the length of time it takes this rise to occur. You also should measured exactly how many gallons of mash you started with, as the more mash, the longer it takes to boil.

The operation of this still is such that the heaviest flow will be at the beginning and slowly taper off until the alcohol flow stops altogether. Check the proof as it gets near the end.

If it begins to fall off, increase the stripper water. You will notice more and more flow out of the runoff. When the alcohol all but stops, check the boiler temperature. This will be the temperature at which your still will have most of the alcohol out of the brew. This is when the heat should be shut off. If the amount of alcohol coming out of the still could not keep the fire going you are putting more energy into the operation than you are getting out.

The liquid left in the boiler contains the acid you added earlier to lower the pH of your brew. This water may be cooled, the solids settled out and fed to hogs, poultry or fish and the

remaining liquid put in the fermentation vat as the second half of the water to cool the brew before adding the second enzyme.

## **RUNOFF**

There will always be some alcohol in the runoff.

Although the quantity may be slight it is a good idea to rerun the runoff. It is much cleaner than the original brew and will clean out your boiler and the plumbing on the way through the columns.

## **CORRECTION AND ADJUSTMENTS**

**Make sure there aren't any kinks in the black heater hose between the boiler and the distillation column.**

If little or no alcohol came out and the temperature in the boiler has risen to the boiling point of water (212 degrees F) the problem is probably not with the system, but perhaps with the fermenting. Be sure you check the runoff. There may not have been enough heat to get the alcohol to the top of the still. With too small a heat supply this could happen. The still is designed the size it is so that you can use heat sources that are normally found on the farm to power it. It can be run at minimum capacity from the burner of a gas or electric stove. This will produce 6,000 to 10,000 BTU/hour of heat.

Too great a heat loss could cause the same problem loss. If you are operating the boiler outside in the winter just a little wind could cause too great a heat loss and all the alcohol could be in the runoff at a fairly high proof or could have run back into the boiler. The boiler and still should both be inside a building.

## **TOO HIGH AN OPERATING TEMPERATURE**

If, the control temperature is much above 173 degrees F when the proof of the product has peaked out (should be above 190 proof), we should make some corrections. This is caused by too much backpressure in the boiler. Unless your pool is very deep, this would be the last thing to change. Within reason, the deeper the pool, the lower the proof of the runoff. Too great a distance between the boiler and the still with too small a pipe is the most likely cause of the problem. The easiest way to maintain the low pressure required (5 lb.) and at the same time provide a blow-off valve for your boiler is to come out of the boiler with a large pipe. This pipe should be 1-1/2 to 3 inches depending on the size of the boiler. Run this pipe up and out the top of the building. Put a metal plate with a rubber ring under it on top of the pipe. Weight this cap until it weighs five pounds. A tractor exhaust rain cap with a rubber seal will work nicely. This provides a pressure release at a safe distance from workers and visitors who seem to inevitably gather around a still, and also provides some stripping action. The line to the still can be tapped off this pipe and will pick up vapors with a higher concentration of alcohol higher up the pipe.

Even inside the boiler, condensation is taking place.

Any piping to the still becomes a part of the distilling process.

What this still is, then, is a controllable cleanup mechanism. This is why we say don't underestimate the amount it can distill. It is also why we cannot say what the hourly capacity will be until the entire system is built. The more stripping that is done before the vapors get to the still the less work the still has to do. Once we get the still to produce the proof we want the capacity can easily be increased by working with the system ahead of it. For example, we could take the water from the stripper coils and run it through coils wrapped around the big pressure release pipe between the boiler and line to the still. This water has been heated in the stripper coils to only slightly below the temperature of the vapors leaving the boiler. It would absorb a tiny bit more heat causing stripping to take place in the vertical pipe but not condensing all the vapors or cooling them to the point that the still would not work.

REMEMBER: What you want is a slowly decreasing temperature from the boiler to the condenser of the still. This is the key to the whole system. As long as you do not shock the vapor with too sudden a temperature change, the water vapor will gradually fall out. Any alcohol that may condense along with the water will have a chance to re-vaporize as it runs back to the warmer part of the still. If you understand all of the principles, you should now be able to build a distilling system with a capacity of many gallons per hour. "Start out small and try larger batches, as you get the feel of what is happening."

Also, I am updating my website all the time, and am always putting up more info and more links. A lot of your questions are already answered for you if you take the time to browse my website a bit more.

[http://running\\_on\\_alcohol.tripod.com/](http://running_on_alcohol.tripod.com/)

If you have any other questions about feed-stocks, fuel use, etc., write to me via the public forum I have created for this.

[Ethanol for Fuel](#)

this is an on-line discussion/newsgroup on making and using your own alcohol fuel.

<http://www.topica.com/lists/robertwarren/>

Subscribe for free, to access archives.

Good luck,  
Robert Warren

## Questions and answers:

> I hope you don't mind, but what is the expected flow rate of cooling water through the still?

> Regards, > Michael

Michael,

This is going to depend on how high the flame is on the boiler. The still temperature changes from minute to minute, and a change in one degree of heat will alter the flow or even turn it off or on in only

one second or less. This is the real beauty of the automatic control valve. It is a bimetal spring-operated refrigeration valve. The bimetal temp sensor is inside a flexible sensor probe, which has a gland nut that fits the 3/4 inch FIP, just below the midsection joint. The body of the valve should attach to the wooden frame you will build to support your valve. The garden hose gets hooked up to the female hose x 1/4 inch adaptor fitting. I do recommend fitting the 1/4 inch water bypass valve as shown in the blueprints, as sometimes this is handy to be able to fiddle with the temperature manually to help you understand what is going on, plus it lets you change the temp quickly in the first few minutes before you get your automatic valve temperature adjusted to the precise setting you will need for your desired output proof.

The cooling water is hooked up to a garden hose, but only flows at a much smaller rate as the cooling water is all constricted by the 1/4 inch tubing it flows through. So Even if your water pressure was really high (this, too, affects flow) the maximum flow will only be at most a liter or 1.5 liters / minute. But it is never steady at this rate: the valve will turn the valve on and off many times in the course of a one hour still run, which is all it takes to distill off the contents of a 50 gallon barrel.

The other thing is the cooling water need not be wasted: you can save it into a barrel or any kind of tank. The water is always under pressure until it comes out the plastic tubing on the bottom cooling water exit fitting. Also, this water is now hot water, so it may be used right away to mix up your next batch and add your enzymes. This will improve the overall efficiency of your process.

-- Robert

## Solar heating the mash

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Robert,

Do you include instructions in your plans for heating the wort with solar heat?

Jason

Jason,

No, even though I am a solar engineer by trade, I don't get into this subject as it makes the whole process a lot more complex, even though the principles are simple. The main problem is precise control of the temperature. The most expensive part of this still is the automatic control valve, which after all these years, I have yet to find a better or cheaper one than the \$300 Penn unit I sell. Plus, it is hard to find this valve, so I usually have to order in 2 or 3 at a time so I have them on hand for people building their own stills. The temp control range of the V 47 valve is 160 to 230 F. There is another version of this valve, called a cross-ambient valve, which will control temperatures in the range of 75 to 135F. This is what you would have to use for the wort (fermentation stock). When adding enzymes, you want to keep the grains or starches warm but never over 130F. Then you let it cool, or perhaps if you are using malt instead of enzymes, then you only heat it to 100 to 110 in the first place, and you want to try to maintain it at this temp for 2 or 3 days. Of course, this is pretty impossible, so even if you decide to use solar energy to bring up the temp to 100 for 4 or 5 hours each day while you have bright sun, this will certainly speed up the fermentation process nicely. The thing is, if you go over 115 or 120F, you will start killing off the yeast organisms, then you get no fermentation at all. Worse, you might end up getting the whole batch infected with bacteria or an acetic acid organism as normally carried by fruit flies, which will turn it all into vinegar, instead (and it can't be converted back to alcohol if that happens).

So, let's say you get your hands on a used solar hot water panel, say one that measures 4 ft x 7 feet, and has two 3/4 inch pipes sticking out the top, and two more sticking out of the bottom. You need to fit a drain valve up to one side of the bottom pipe, and the opposite corner from this one you need to fit with a high pressure blow-off valve, such as the T & P valves used for a hot water tank, which will open or "blow" when the temp gets up to about 250F. This won't keep the batch from overheating and killing your yeast, but it will protect you from a big explosion if something goes wrong. Then the two other pipes should be hooked up to a closed loop system (including an expansion tank) in which you fill it with some kind of glycol, such as car antifreeze 50% and water 50%. The bottom end of this loop can be made into a coil using 50 ft. of 1/2 inch soft copper, which gets inserted into the fermentation tank. You never circulate mash through the solar collector directly, as it will clog up from the particles of grain or other starches. This is an indirect method, but it can work well, if you use your head and put temp controls in the right place.

You will also need a pump and a differential controller, and the whole thing gets a bit complicated. You see, once the sun is shining, you can't just turn off the flow when the solar heating loop gets so hot as to sterilize and kill the yeast, or it will just keep getting hotter inside the solar collector panel and the overtemp valve will blow! So you have to use the temp control valve to divert the heat into a second tank of cold water. I am not going into any more on this subject right now, but if you have more questions about this, I can answer them on line on the on-line discussion/newsgroup.

--Robert Warren