Primitive water distillation construction notes and lessons learned

(13 Jan 05)

Four different basic ways of distilling water are tested and the lessons learned are discussed. Gradient steps in complexity of construction are shown. Any one trying to distill water will most likely be going though the same learning pains. Hopefully if you read and understand this you can stand on what I have learned and start at that point to design what you can build taking into consideration what you have available to use.

1) Can sheet metal or large surfaces be used to distill water evaporated from an open pan etc? Answer: Technically Yes, but practically No. If one needs a practical way to produce drinking water before one dies of thirst this method becomes very problematic. This method will produce a small energy inefficient amount. I was able to get about one or two drops every 10 sec by using this method. see open aluminum duct http://home1.gte.net/mikelob/Tea_Pot_ends_open.JPG.

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It is easy to produce way too much steam and overwhelm the cooling area, which needs to be as large as possible. If one produces too much steam it keeps the condensation area hot all the time and thus no condensation takes place. One will not be able to regulate the source of heat in a primitive environment thus this method could be a problem.

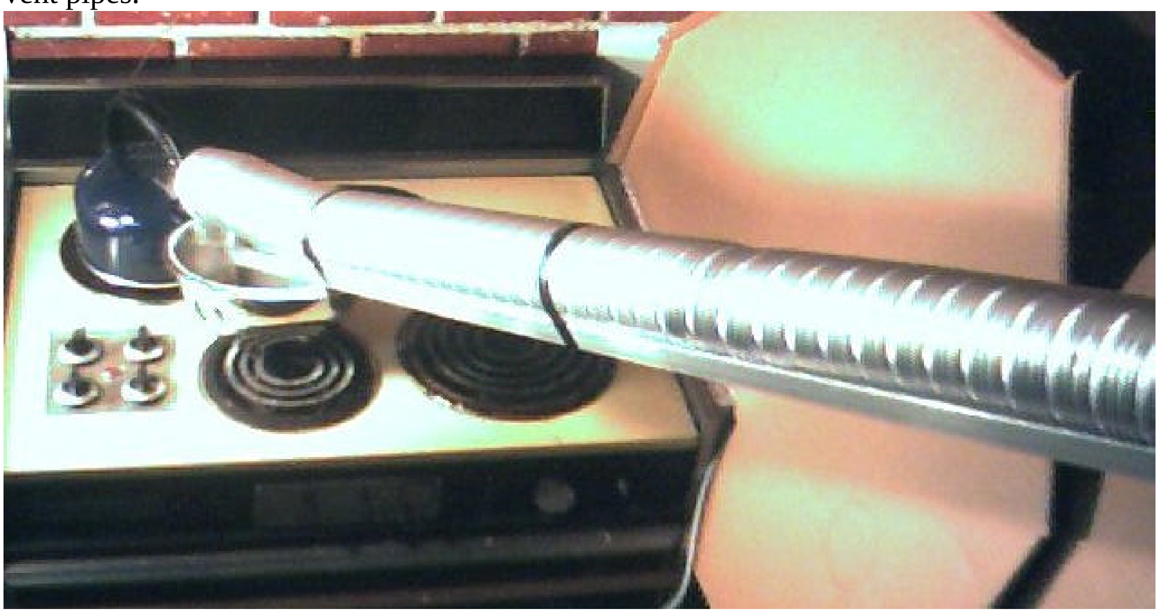
Another big disadvantage is if the relative humidity is too low (say below 40-50%) then condensation will evaporate before it runs off. This method then will not then work. The source of heat whether burring wood, gas, or electrical has a tendency to produce hot dry air above the fire that will rapidly evaporate the condensed steam. In other words one needs to transport the steam a bit away from directly above the fire area before trying to condense it.

Sometimes it helps to slightly cap off the ends to reduce the flow. See http://home1.gte.net/mikelob/Tea_Pot_ends_closed.JPG .

If there are contaminates in the surrounding air that are settling out (like volcanic ash) then this open process will allow the distilled water to become contaminated again.

Bottom line: The open-air process is the problem in this method it introduces too many variables. After a PS in a primitive environment one needs a controllable process that can be repeated under widely varying weather conditions.

2) What about using a nearly closed area for condensing steam? This works better than the above open sheet method but is still not that practical in a primitive environment due to the need to carefully control steam flow, and the size of the cooling area needs to be large. Again too much flow easily overwhelms the surface area and will produce no or a small amount of distilled water. The heat from the fire producing hot air needs to be directed away from the condensing area. For this method one can use 10 foot galvanized steel roof rain down tubes, air-conditioning duct piping without insulation, or sheet metal vent pipes.



The tests http://home1.gte.net/mikelob/3inch-Ducting.JPG were done using only one section of aluminum 3” vent flexible pipe 7 ft long. The open upper end needs to be nearly closed off so that it limits the steam flow. When properly adjusted, I was able to get 1 cup of water every 1.5 hour using this 3” by 7-foot method. If one had enough of these pipes and a way of directing the steam flow into each then one could produce sufficient water for drinking. One advantage of is this method is it can be made to limit the contaminants in the air from entering into the distilled output.

Speculating now, if one had the space to do it, probably outdoors; one could build a porcupine looking half circle made out of 5-10 rain down spouts. One would take a bunch of these 8-10 foot rectangular tubes made out of galvanized steel, and join the open end (down ward direction) in a hemisphere shape. The upper closed end would have a small hole that could be adjusted by partly closing it off to maximize water output. I am thinking the ones that are nearly vertical would work best with a small air escape hole, and the ones that are more diagonal would work best with a slightly bigger hole. The water would collect on the inside as the outside cools off. As the water runs down the pipe and gets close to the end there could be smaller catching tubing that could be positioned to allow the water to run off into a collection point. The fire would be built off to one side and the steam diverted by use of air ducting into this hemisphere. Heat from the fire would be directed away from entering the tubes.

Another idea: I bet one could take 2 garbage cans or two 55 gallon tanks or any 2 large metal containers and make a water distillation unit. Visualize two garbage cans lying horizontally on something that blocks it about 4 or 5 ft off the ground. Set the bottoms facing each other and flush with each other. In the center off to one side (not under the cans) visualize a fire built with water in a pan above it. Run an air ducting vent pipe from over the boiling water to divert the steam into a cut hole in each can. This would be big enough to allow the steam to enter near the bottom of each can (right over the steam). The cans have their lids in place and taped shut. A small hole (let the air out) may be needed in the lid to tune it up to producing maximum distilled output water. Because of the tapered shape of a garbage can the water would run toward the lid of the can and out into a small catching container.

All of the above methods use air to take away enough heat to allow the steam to condense as water this takes a lot of surface area if no movement of the air is present. It would be much more efficient to use a fan on the outside of the cooling surface. However, in a primitive environment this will not be likely due to then need for electrical power, thus I did not do any testing in this direction.

If one had available a car radiator or car heater unit turned diagonal and allowed steam into the top in a slow controlled way so that no steam came out the bottom then one could collect the distilled water as it ran out the bottom. This would take some cleaning and purging of used radiators to get all the foreign chemicals out.

3) What about using a bucket of cold water and coils of copper tubing to condense the steam? This approach is basically building a simplistic water-cooled heat exchanger. The input reservoir can be a commonly available pressure cooker of any size. Alternatively the input reservoir can be made from any able to be closed container. Not much pressure is involved so theoretically it could even be made from a paint can in a pinch. I used a 4.2-quart aluminum pressure cooker that took about 15 min to start producing output once it is turned on from a cold start. Using the attached test set up http://home1.gte.net/mikelob/Coil_Exchanger.JPG and http://home1.gte.net/mikelob/coil_exchanger-detail.JPG

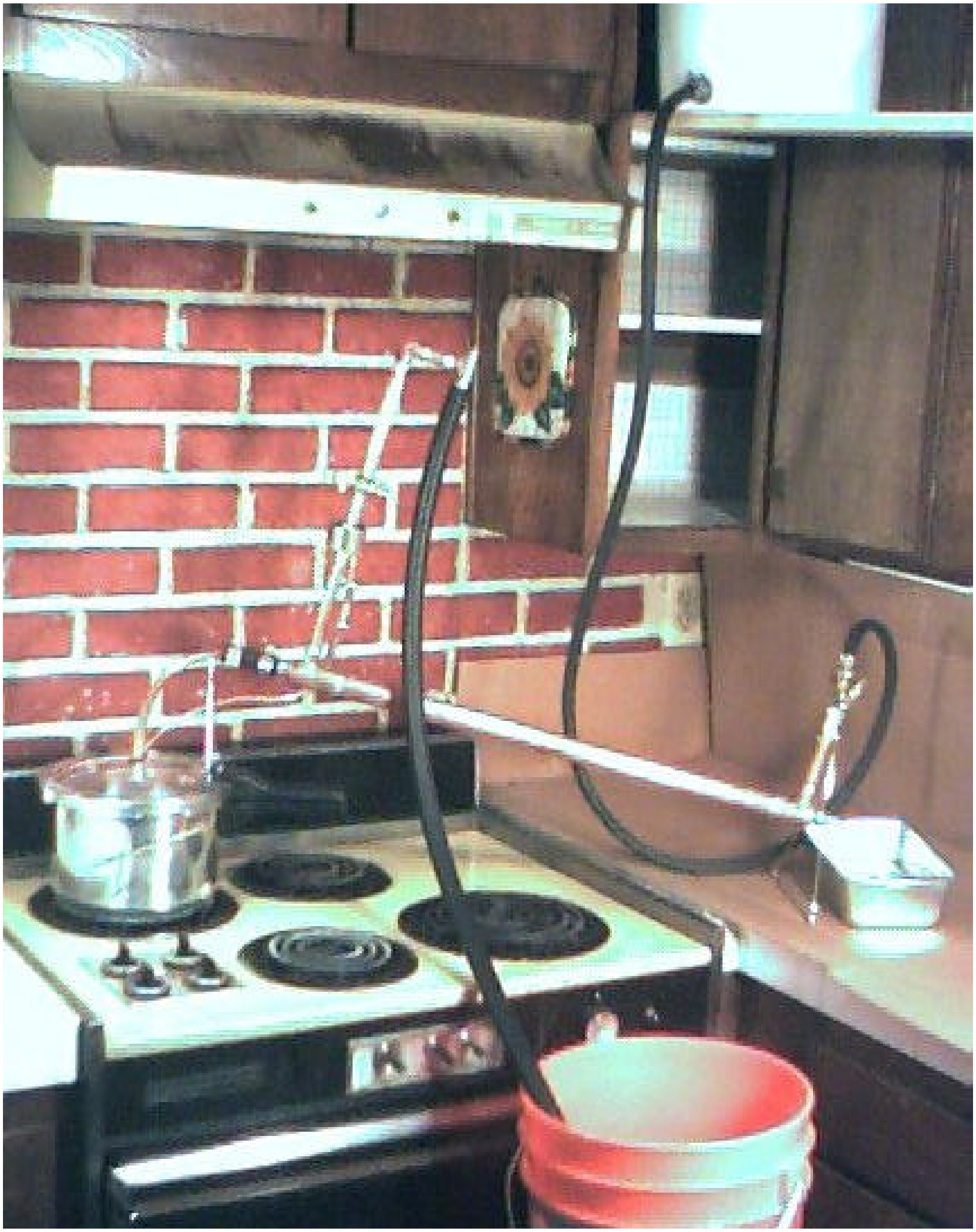
I was able to produce about 6.5 cups/hour of distilled water. The input source was an electric stove 240 volt x 7.3 amps = 1750 watts. Note that water is replenished from the upper reservoir at the same rate it is turned to steam by adjusting the needle valve on the supply bucket and keeping tack of the level by use of the site gauge (silicon rubber hose) on the side of the pressure cooker.

I found the water in the heat exchanger bucket gets extremely hot (from top down) and needs completely changing approximately every 35 min. This is a messy process in that when the tank is drained the copper coils get extra hot and the output hose and rubber seals get very hot. For good tasting water it is not good do to this extra heat on vinyl or rubber parts and it also tends to introduce leaks in the bottom of the exchanger tank where the copper tubing makes its seal with the stainless steel bucket. After a couple of hours of running I didn't consider this design to be good enough for day-to-day production unit worthy of a primitive environment. One could defiantly not walk away from it and leave it unattended. It would take constant maintenance and attention.

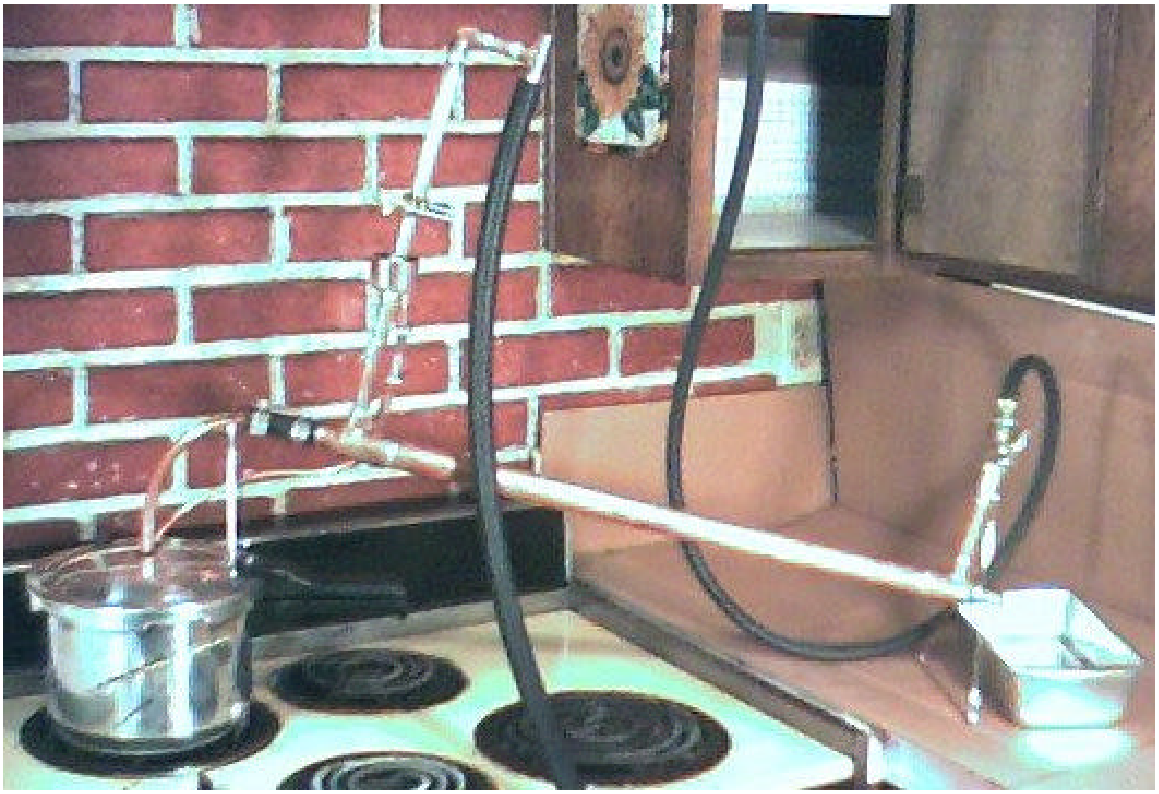
Also the resulting water had a strong vinyl taste to it. As a result, I don't recommend using vinyl on any output part of the distillation system. Along the same line, any hydrocarbons (oils) that are in the water before distillation will end up in the output having been evaporated and then condensed back into the output water. Thus taste will be a problem using this method because of the estimated large amount of hydrocarbons (oils) found in the after PS available water.

Also the method of measuring the water level in the pressure cooker needed some redesigning. Silicon rubber fish tank air hose will soften and swell up and eventually split open or leak at the ends. I initially tried to use this for a water level indicator and rapidly found it was not practical. Vinyl is worse it will swell, turn white, stretch and becomes very soft so it is not very usable on the hot output side. Glass tubing would work but is not available or practical in a primitive environment.

4) What about using continuous but controlled flow of cold water in a closed heat exchanger to condense the steam? What about, in order to improve taste, evaporating the dissolved hydrocarbons before introducing the water into the boiler? This approach is basically building a water-cooled heat exchanger by using copper pipes and fittings. See the linked test set up http://home1.gte.net/mikelob/Exch-Full.JPG.



This approach also has incorporated lessons learned about heating and evaporating the hydrocarbons in the incoming water to the boiler. Note by dripping hot waste heat exchanger water into a small copper cup, it looses it hydrocarbons into the air. An efficient heat exchanger can be made out of .5" and 1" copper pipe and T-fittings for the end see http://home1.gte.net/mikelob/Exch-Full-1.JPG.



Using the same electric stove producing 1750 watts and no insulation on the hot spots, after one hour I measure 2.8 Gal of 140 deg F waist hot water and 6 cups of output distilled water at about 16 degrees above room temperature or 86 deg F in my case. This is about 1.5 quarts/hr or 9 Gallons/day. More heat or more insulation and it would produce more output water. More units or a bigger pressure cooker and several heat exchangers running off the same pot in parallel would also produce more output.

General Construction and Adjustment notes:

Be sure to remove the bur off the inside of the ¼" copper pipe that solders to the open-air-replenish-cup. With the small hole the inside bur leaves after pipe cutting it will sometimes cause the cup to overflow (depending on surface tension of the water at the time).

The saddle clamp needle valve was about 2.6 turns open for operation. The water valve to the bottom of the heat exchanger was open about 1/8 to ¼ turn. I used a typical stop valve that has a rubber washer in it. This changes dimensions while in operation depending on temperature. The result is a need to constantly adjust the flow rate. I would recommend using a ½"gate valve instead. This has no rubber parts and the flow once adjusted will not change with temperature. See http://home1.gte.net/mikelob/Exch-Fosit.JPG

Rubber hoses works much better than vinyl but one cannot see though it. 5/8-inch car heater hose was used for sealing the ½ inch tubing (outside diameter) that was slipped into the ½ inch copper pipe (inside diameter) of the heat exchanger. This same hose was used for the output wastewater. I don't recommend using hose on the output of the heat exchanger for the good distilled water. If one gets steam coming out (too little water flow in the exchanger) then the taste of the hose will get into the distilled output water.

The flow of cooling water in the heat exchanger can be adjusted by measuring how hot outside 1 inch pipe gets along it's length. If one is careful one can use ones hand. Start at the cold end and gently move along the pipe to the point of needing to take ones hand off the unit. One wants to adjust the water flow so that it never gets hot at the cold end and is hot to no less than the center of the length. This is all depending on how much water you want to heat to what temperature. Generally one can do 130 to 180 degrees F for wastewater out of the heat exchanger without insulation.

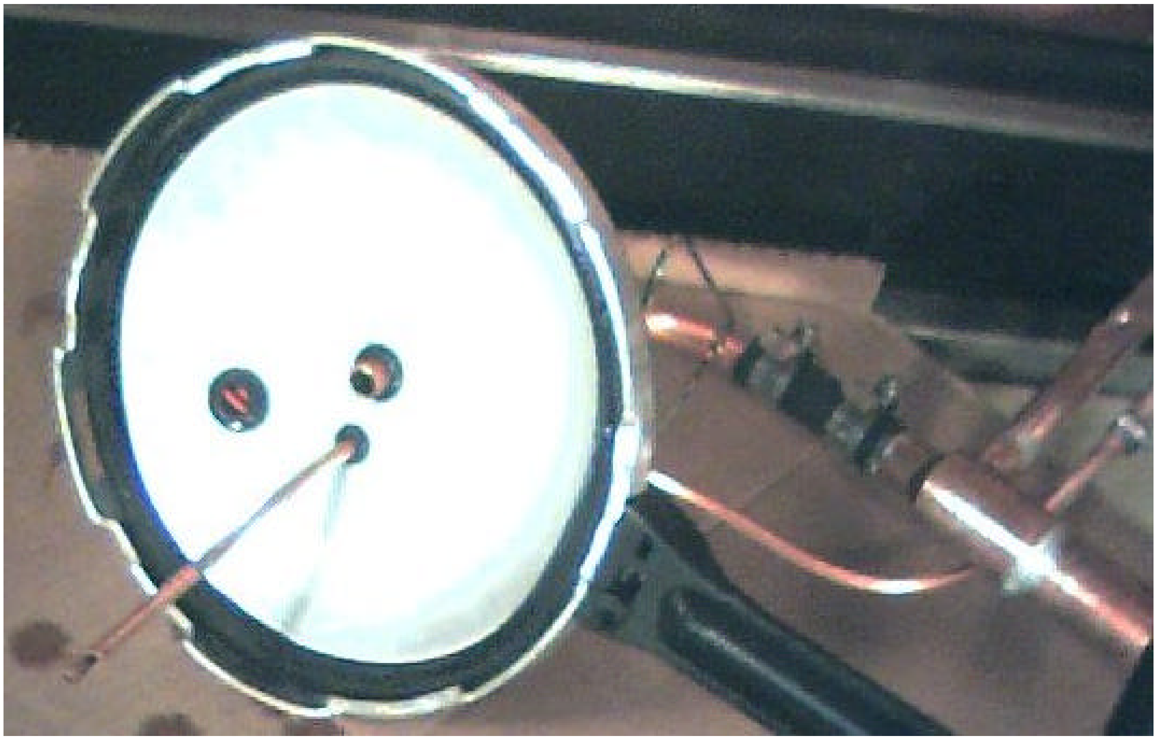
Measuring about 140 degrees at the boiler replenish cup is about typical. See http://home1.gte.net/mikelob/Replenish_Cup.JPG. If one has a lot of taste (hydrocarbon) in the result then one wants to get the replenish cup up to as high a temperature as possible by slowing down the cooling water in the heat exchanger. This will cause the hydrocarbons to boil out of the water as it drips though the open air between the needle valve and the open copper replenish cup. The cup has a baffled barer in it that blocks the surface of the input from reaching the output side. This keeps the lighter hydrocarbons (oils) on the input side until they evaporate. The output .25" tubing is positioned a bit off the bottom of the cup.

Insolate to keep the heat in the cup on down to about 1/3 of the heat exchanger and the full length of the exposed ¼ pipe that goes to the pressure cooker See http://home1.gte.net/mikelob/Replenish-cup-Inso.JPG

and http://home1.gte.net/mikelob/Exch-full-Inso.JPG. Insolate to keep the heat in the top of the pressure cooker and the pipe leading to the exchanger. This will make the operation more efficient.

One can always make some charcoal by heating wood in a closed chamber and burning the gasses that come off to help produce the heat necessary. The charcoal can then be used to take the hydrocarbons out of the distilled water by filtering it though a container full of crushed charcoal. Hopefully this will be un-necessary if one can pre-heat the water enough to drive off the bad tastes.

Silicon rubber II sealer seems to hold up well in the steam environment and can be used to seal the pipe going through the top of the pressure cooker if a rubber grommet is not available. See http://home1.gte.net/mikelob/Exch-Lid.JPG.



A rubber grommet from the firewall or from the PVC valve from a junk after PS car may be able to be used. The grommet used for the safety valve in the pressure cooker may be able to be used. By the way I found the new “step drill bits” to be quite usefully in drilling the hole in the lid of the pressure cooker and when needed in the side near the bottom for supply 5 gallon buckets.

A float was used to measure water level inside the pressure cooker. See http://home1.gte.net/mikelob/Float-Indicator.JPG.

It was made out of a large inline disposable gas filter with the ends cut off and soldered up to make it air tight. See http://home1.gte.net/mikelob/Float-Hing-1.JPG.

3/32" Brass brazing rod was used for the float hinge mechanism. Any other type of wire would also have worked including coat hanger wire. Small copper pipe about 3/16 inch was used for the outer hinge and was epoxied to the aluminum pot by use of copper epoxy. The copper epoxy is designed to replace solder and is sold at home improvement stores like Home Depot.

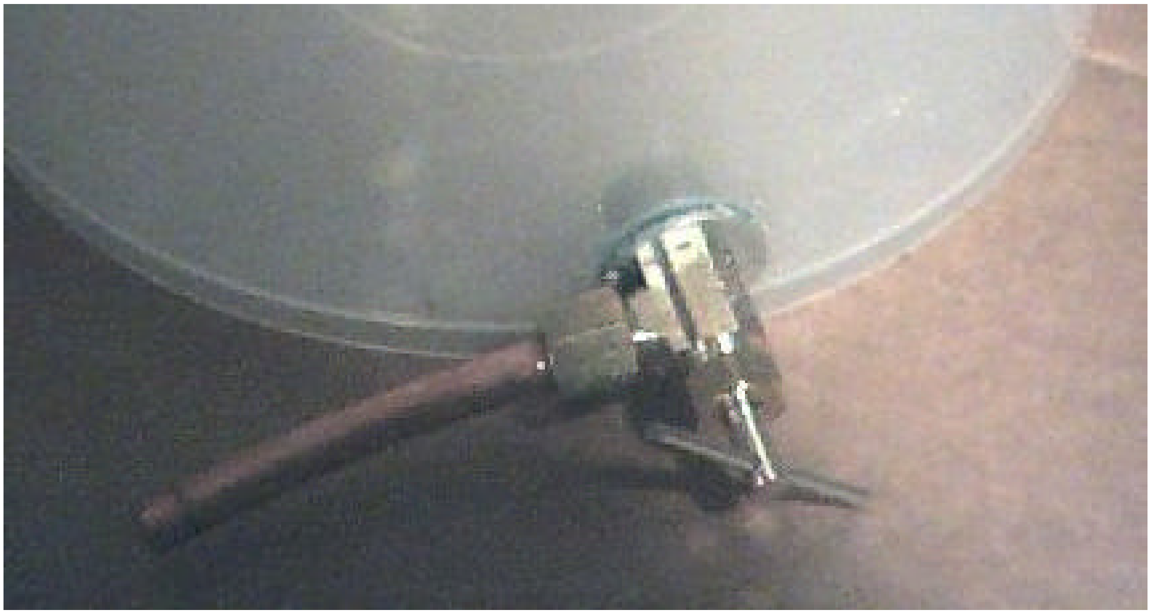
The ½ inch pipe that comes out of the top of the pressure cooker and the inside pipe of the heat exchanger needs to be just big enough in diameter so as to not build up a back pressure in the cooker. Bigger pots and hotter fires may need a bigger pipe or more than one heat exchanger may be needed..

Occasionally the pressure cooker will need to be shutdown and the contents empted out to dispose of the salts that build up. The frequency will depend on the dissolved mineral content of the water.

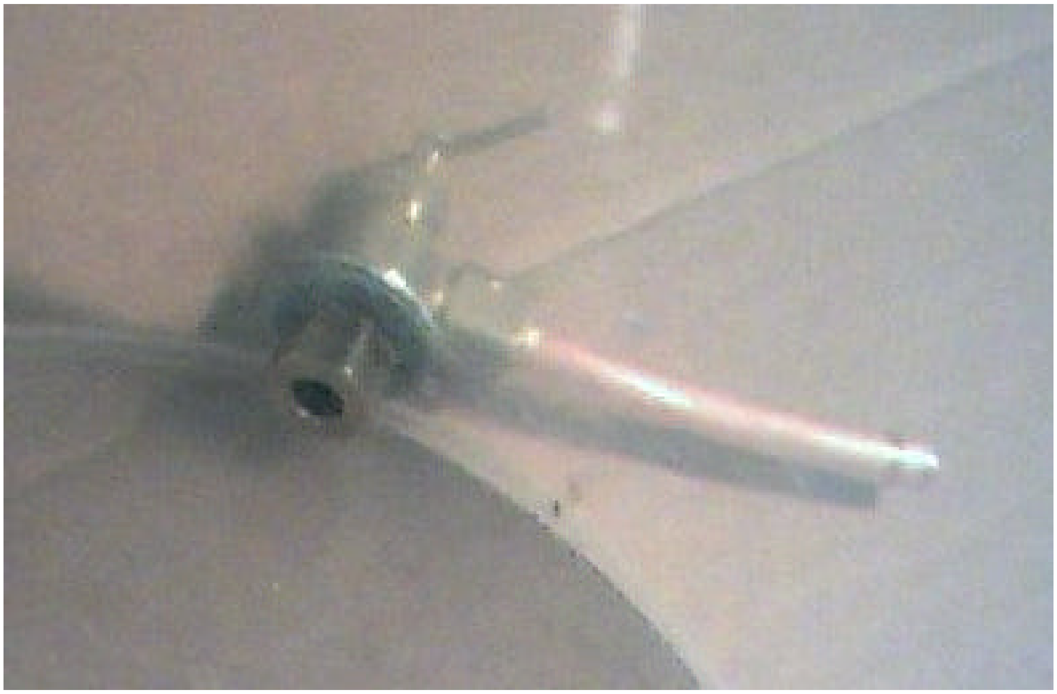
Water taste: Using the copper coil approach the output had a strong vinyl hose taste. Using the last approach with the heat exchanger and the hot water dropped through open air to remove hydrocarbons before entering the boiler chamber resulted in very little taste.

A bucket feed through for water outlet can be made using a barbed hose fitting with pipe threads or a needle valve. See http://home1.gte.net/mikelob/Bucket-Feed.JPG

or http://home1.gte.net/mikelob/Bucket-feed-1.JPG



or http://home1.gte.net/mikelob/Bucket-feed-2.JPG.



Metal washers are used on both sides of the bucket. A coupling or another pipe fitting is used on the other side to tighten the washers down on the bucket side wall. Silicon rubber type II is used to seal the connection. Amazingly enough standard washer sizes work fine. For example for .25" pipe thread one uses two .5" metal washers.

Summary: Open air-cooled steam distillation introduces enough variables that practical day-to-day distillation is not likely. Heat exchangers that make hot water as a by-product look the most promising for primitive water distillation.

All of the above methods assume some sort of heat source that can produce steam. This assumption could be a problem for many areas due to the near constant rain and lack of firewood, coal, tar or other burnable resource. Some areas will be able to use hot earths crust to great advantage.

Warning: Hot Steam, hot water and hot metal will cause server burns as it transfers it heat to the skin of the body rapidly.

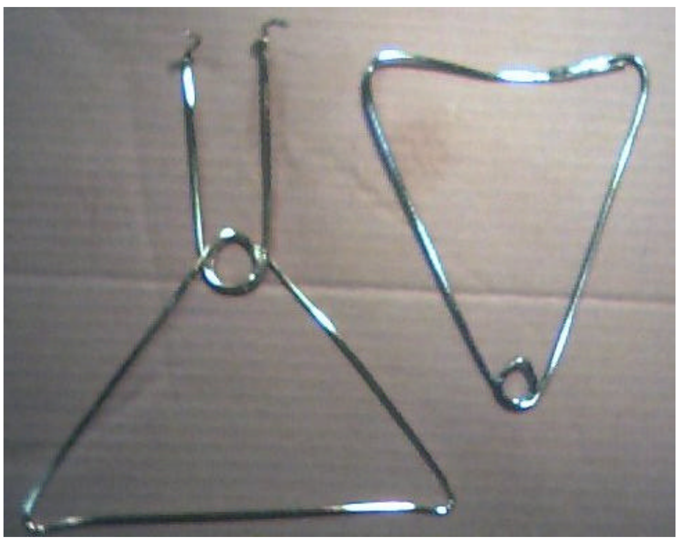
The amount of heat given off when steam changes back to water is 540 calorie/gram (called heat of vaporization). The amount of heat it takes to raise one gram of water one degree C is 1 calorie. Thus one can see a lot of heat is capable of being transferred to the skin for very little amount of steam.

Using these numbers it is easy to show that one can expect to produce hot waist water of about 7 (above 190 degree F) to 14 (above 140 degree F) times more volume of output water than the input water that was converted to steam in the first place. This assumes a room temperature of about 70 degree F as the starting temperature for the water.

List of parts for the last approach, number 4:

The unit was built to be broken apart and shipped in a standard home Depot box no bigger then 18" by 18" by 25". Recommend using only lead free solder. Your prices might a bit different I included my current cost.

Quantity - Description:
2 coat hangers (used to make the support for each end of the exchanger) see http://home1.gte.net/mikelob/Coat_Hangers.JPG



http://home1.gte.net/mikelob/coat_hanger-1.JPG

1 29" by .5" copper pipe (about $1.10)

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1 23.5” by 1” copper pipe (about $3.00)
2 1” by .5” by .5” copper Ts (about $4.50 each)*
1 14.5” by .5” copper pipe (about $ .60)
1 4” by .5” copper pipe (about $.20)
1 2” by .5” copper pipe (about $.10)
1 .5” copper T (about $2.00)
1 .5” copper 90 degree elbow (about $1.98)
1 10.5” of soft copper tubing .5” OD (about $.80)
1 .5”solder by .75” garden hose water valve ($4.25)
1 20” by .25” copper tubing ($.30/ft)
1 .25” Self – Tapping Saddle Valve or Gate Valve if you can find it ($4.92)
1 1.5” copper end cap ($2.00)
1 6 ft washing machine input rubber hose (3/8” ID) one end cut off ($6.00)
1 6 ft of 5/8” car heater hose ($4.79)
5 hose clamps ($.69/each)
1 Barb 3/8 by 1/4 pipe tread for bucket feed though to hose. ($1.29)
2 ½” washers for bucket feed though (one inside, one outside, silicon rubber seal in-between) ($.13/each)
1 1/4 inch pipe coupling for bucket feed through (for inside bucket) ($.69)
1 Purolator (F20030) fuel filter (pep boys) for float in pressure cooker ($3.99)
1 4.2 Qt Aluminum pressure cooker (Mirro brand $17.57 from Wal-Mart)
1 3/32 inch Bronze welding rod. ($.25)
1 3/16 small length section of copper tubing was used for float hinge ($.40)
1 5 Gallon paint bucket for supply water ($3.00)
1 9/16” id rubber grommet ($1.54/3)
1 ¼” ID rubber grommet ($1.54/6)
1 pipe insulation ($1.19)

Total is about $74 for parts.

* This was the hardest item to find. I needed to go to a pipe supply place. I in a pinch believe you can use .75” x .5” x .5” pipe and fittings from local home improvement stores if you can not find this 1” T. The 1” versions are better and worth looking for see http://home1.gte.net/mikelob/Exch-Left-big.JPG.

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Deburring of the ridge inside the .5” end of the copper T is necessary for the .5” pipe to slide all the way though to the other end. This can be done with a round file or a rotary rasp on a drill

Assembly instructions after shipping to your destination:

1) With the pressure cooker lid in you lap slide in the output pipe down from the top.
2) Put the insulation on the top of the lid sliding it around the pipe if you are using it.
3) Insert the .25” pipe into the lid from top down.
4) Put the lid on the pot.
5) Install coat hanger support on faucet end of exchanger
6) Marry up the exchanger with the .5” pipe on the pot.
7) Tighten all hose clamps.
8) Hook up hoses to the supply bucket.
9) Put a container under the end of the exchanger to catch the distilled output.
10) Put water in the pressure cooker.
11) Fire up the heat.
12) Adjust the flow of water through the heat exchanger once producing output.

MikeL

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