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Hello all,

I live in an older small house (< 1000 square ft.) built in 1892. I am going through the whole house, meticulously insulating it with expanded poly styrene board. I tore off the lath & plaster, increased the thickness of my walls, and I'm layering in 6 inches of rigid foam into the walls, ceiling, and under the floor.

So I'm thinking ahead to a highly efficient heating system. As best as I can determine, a Ground Source Heat Pump (AKA: GSHP) running warm water though a thin (1.5 inch), radiant concrete floor is my best bet.

I don't have much money, but I am resourceful and very stubborn.

I have found out that the approximate size of a heat pump I'll require is slightly under 12,000 BTU/hr. In HVAC speak they call 12,000 BTU/hr a 'Ton' of Air Conditioning. Your mileage may vary.

I have also found out that here in Western Oregon (Portland), a GSHP will require a borehole about 200 feet deep. It could also be two boreholes about 100 feet deep, etc... Again, your mileage may vary.

I also found out that heat pumps are classed as Air-to-Air, Water-to-Air, and Water-to-Water.

The kind I need is Water-to-Water. The kicker is, that the smallest I have been able to find is four ton (48,000 BTU/hr). So this means that in order to proceed with the project, I'll have to build my own heat pump. In HVAC, bigger is not better... just slightly smaller than big enough is best, economically speaking.

A properly designed system as I'm describing should be able to operate at an efficiency of over 300%. My prototype has actually shown efficiency over 400%. In HVAC, efficiency can go over 100%, because the electrical energy that is input is not directly converted to heat, but is being used to move heat from one place to another. Strange but true.

So there are four parts to the project:

1. The Ground source loop field.

2. The Heat Pump.

3. The radiant floor system.

I'd really like to get other people interested in this kind of project. Commercial units installed run $15,000 to $45,000 and up. I'm estimating that I can get mine going for under $2,000. Maybe under $1,000.

So Let's Get Started!!!

I started by making a T-handle test drill, that used a water hose, connected by a swivel coupling.

This is my first test drill, only with a shorter piece of drill pipe, so you can see what's going on.

I actually used a 6 ft. section of pipe and when the auger advanced about 5 ft., I added an additional section of pipe.

I was able to advance about 13 feet in about 35 minutes. One problem I encountered was that the hose kept kinking, so I had to hold it up with one hand and I turned the auger with the other hand. So I was able to advance 13 feet with only one hand.

The other, and more serious problem was that because of the high sand content of the soil, I was having cave-in problems.

I didn't know what was causing it, I just knew that my auger was getting stuck and was very hard to pull out of the ground. Later I would discover that drilling mud would solve the cave-in problem.

This is a detail of the swivel end of the auger. The swivel adapter is not exactly the same as 3/4 pipe thread, but by loading lots of teflon tape onto the threads, I got a satisfactory seal.

This is a detail of the business end of the auger. The water gushes through the pipe and flushes out the drill-cuttings. I have come to understand that the water is definitely part of the tool. It contributes more to the advancement of the drill than any effort on my part.

I live at the top of an 80-foot bluff and look down at a local river. I did notice that I was hitting rocks at about 12 to 13 feet. What I didn't realize at the time, but have come to know that every well driller understands very well, is that 14,000 years ago, an ancient flood deposited about a foot of clay mixed with basalt river gravel which over fourteen millenia has consolidated in what the locals know as 'hardpan'... it's tough stuff.

At the time this was written, I thought I had, indeed hit hardpan. Later work, using tools that didn't obscure the nature of the soil I was digging through, revealed that I had actually hit an area of fist-sized rocks left from a 10,000 year old geological event. I developed a tool (the "steel claw"), shown later, that enabled me to remove the rocks and advance town to a depth of 17 feet where there was very wet, coarse black sand, very good for Ground Source Heat Pump work and worth the extra digging. At that depth, I was actually able to look down boreholes and the see the hardpan layer.

You may not have anything like this where you live. In fact, a couple of blocks from here, thing might be much better, or much worse.

This is the base of the gearmotor auger I put together. Based on my hand-drilling experience, I figured a small motor would do the job, so I got a 1/4 HP 25:1 permanent magnet gearmotor off ebay for $70. A 1/4 HP motor doesn't require a huge amount of structure to support and control, so fabrication was pretty easy.

This is the gear motor head. I fabbed an 'L' bracket for the motor and used a 2" square tube for the vertical, and a close-fitting 2" inside receiver tube welded to the L bracket. it slides up & down well and doesn't have too much slop. You can see the hand cranked wench to raise and lower the gearmotor head. It's not optimum, but it works OK.

(By the way, I'm a terrible welder. I have a stick rig, which I have tried repeatedly to master, but it has won every time. So, I bought a crappy little wire-feed welder for $100 and it has worked wonders. Highly recommended.)

The gearmotor I chose is permanent magnet, so I can reverse the direction to unscrew pipe... very handy. I also have a bench test variac that I use to control speed. Works great.

How to weld the pipe together.

I've been wracking my brain, trying to figure out how to join the pipe that will eventually become my ground-source heat exchanger.

I know that PEX is pretty good stuff, but because of the way the PEX plastic is made, it can't be welded.

PVC and CPVC is out of the question because it gets brittle.

I've noticed that in all the sources I have read, High Density Polyethylene (aka: HDPE) is the pipe of choice, with 3/4" being the size often used for small, home-heating applications. If the Ph of your soil is not acidic, copper would be good too, but very expensive. So in practice, HDPE seems to be the choice, with life-spans of 50 years guaranteed, and life-spans of 200 years expected!

The only catch is that many states require that the HDPE have all joints & couplings being welded. Since I'm going to be doing this myself, I have considered many alternatives to welding, including barbed connectors and stainless steel hose clamps... should last a good long while.

So, I was at the local gigantic home-improvement store, looking over various kinds of plastic pipe, and I saw big rolls of black polyethelyne water pipe. I zeroed in on the 3/4 pipe and saw that they have two grades, schedule 40 (100 psi) and schedule 60 (160 psi). The schedule 40 was too thin to consider, looks like it could be crushed by the force of the earth above. The schedule 60, however looked really pretty good.

So I bought a short length of the schedule 60 and went looking for possible joining solutions. At a high quality (professional) plumbing store, I did find some very nice looking brass barbed joints which would use stainless hose clamps. I also did some asking about as to welding tools. Turns out that there's a company named McElroy that makes a tool called MiniMc (pronounced 'mini-mac'), that consists of a teflon-faced heating tool, a ratcheting facing tool, and a gripper/slider tool that holds the pipe while it is being faced, heat-melted, and fused. See photos, etc here: (McElroy MiniMc Fusion Machine Overview). Also check out the manual, photos, animations, movies, etc. Quite an education! The local outfit sells the tools for nearly $2000 (OUCH!) they'll also rent them for $45/day or $180/week (gasp). But this doesn't really look like rocket science...

So, on the way home, I stopped at my favorite junk store and got a teflon skillet, to try a wee bit of free-style polyethelyne welding. I put a chunk of aluminum plate on the stove burner, and put the teflon skillet on top of that and set the gas flame as low as it would go (my stove has 35,000 burners). I used an infra-red thermometer and set some short lengths of Polyethelyne upright on the skillet. When the heat got up to about 300 degrees, I noticed a small bead forming on the pipe end, where it met the skillet. I picked up the pipe in my hands and pushed the hot ends together, and to my amazement, welding was happening!

Photo of my first try

Photo of my second try

This stuff ain't rocket science. I mean if I can get this close on two tries with a teflon skillet, this is possible!

There are two types of HDPE fusion welding being done, butt welding and socket welding. In pages that follow, I demonstrate how I successfully made a butt welding paddle out of a heavy teflon skillet ($4), a removable electric skillet heat-controller ($3), and a heating element from a mini-panini maker ($4), all parts from a local thrift store. The electric welding paddle worked very well, and I am still using it.
The second type of HDPE welding, socket welding, requires Teflon coated parts of a precise size, that cannot be found on the second-hand market.

[Source for socket Faces...]

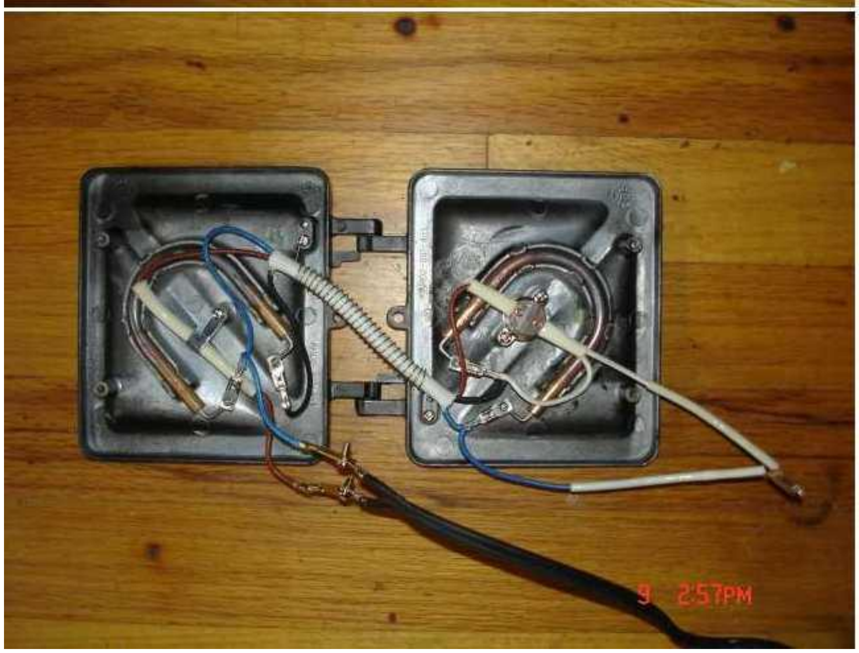
How to build a DIY welding device.

I took my Polyethylene weld tests down to show Howard-the-Machinist this morning. When I showed him what I was able to do with a Teflon skillet on the kitchen stove, he was rightfully impressed. So impressed in fact that he volunteered to do some destructive testing to see how good the welds were. He fixed a 3/4 piece of steel rod in the bench vice and used another piece of 3/4 rod to try and tear the welded pipe apart. One weld broke pretty easily. It was a weld on which I had tried minimum heat. You could see at the torn cross-section that some of the end was still shiny and had not even melted from the heat of the skillet. The other welds were so strong that the poly pipe gave way before the weld did. Pretty impressive. But I can see just how much better it would go with a device that was along the lines of the Mini-mac. So could Howard. He showed me some online sources for 'cartridge heaters' that came in various wattages and temps. They ran about $35 each. He also said that he'd mill out a chunk of aluminum for the cause

Before I left I introduced my Teflon skillet to Howard's bandsaw.

This will give me non-stick surfaces for fusing the poly pipe.

On the way back home, I stopped into Goodwill to look for resistance-heating devices I could savage to heat my home-made polyethylene fusion machine(AKA: 'Mini-Hack'). I had plenty to choose from: hair dryers, clothes irons, waffle irons and finally I found just the thing... a mini electric sandwich maker:



This device drew 600 watts, which I properly guessed ran 300 watts per side:


120V 1300W
9 3:02PM


9 8:16PM


CEN-TECH
CAUTION
327

I have passed over the mini-sandwich maker's thermostat because it doesn't allow the heat to go high enough. I have instead decided to go with an electric skillet temp controller because it allows temperatures up to 450 degrees F.

So here is my current thinking on how to de-technify a device to precisely join poly pipe for fusion welding:

In the background is the jig for centering the pipe. I built it on a large L-bracket. The smaller angle was welded in place first, before cutting out the section from the middle, thus assuring that the two sections would be in line. Since my house is small and well-insulated, it will require a pretty small loop field, so I'll be able to get by with just 3/4" pipe. The operation will require two people, one to hold the heating iron, the other to hold the pipe in place and to apply force on the pipe when the fusion temperature has been reached. In the foreground, bottom-right is the electric skillet heat control (temp control goes over 450F), in the mid-ground, middle left is the heat-cell which I made from the band-sawed Teflon skillet and the 300 watt mini-sandwich heating element.

P.S.: I've located some good, free industry literature. The Plastic Pipe Institute (there is such a thing) has a book called Polyethylene Pipe Handbook which can be downloaded chapter at a time here: [Handbook of PE Pipe]

...of special importance is the chapter on "PE Pipe Joining Procedures" located here: http://plasticpipe.org/pdf/chapter09.pdf

Heat Transfer Test

Most of the sources I respect advise doing a heat transfer test to determine the rate at which heat will be transferred into the earth (for cooling) or out of the earth (for heating). This transfer rate will be the same in each direction, and will determine how much loop-field (trench or borehole) will be required to heat or cool your house. This is important because the loopfield is the most expensive part of the GSHP installation process if you are hiring it out, and is a lot of work if you are doing it yourself. So it's a good idea to get it right. Too little loop-field won't be able to supply the heating or cooling required. Too much, while not such a bad idea, means greater expense and greater work.

So I went on a google-frenzy to try to locate testing and evaluating proceedures, and after many, many hours, finally turned this up:

http://www.geokiss.com/tech-notes/TCTestingSum.pdf

So, I consider this test to be my first attempt at testing and likely to be a candidate for improvement, but this is what I did...

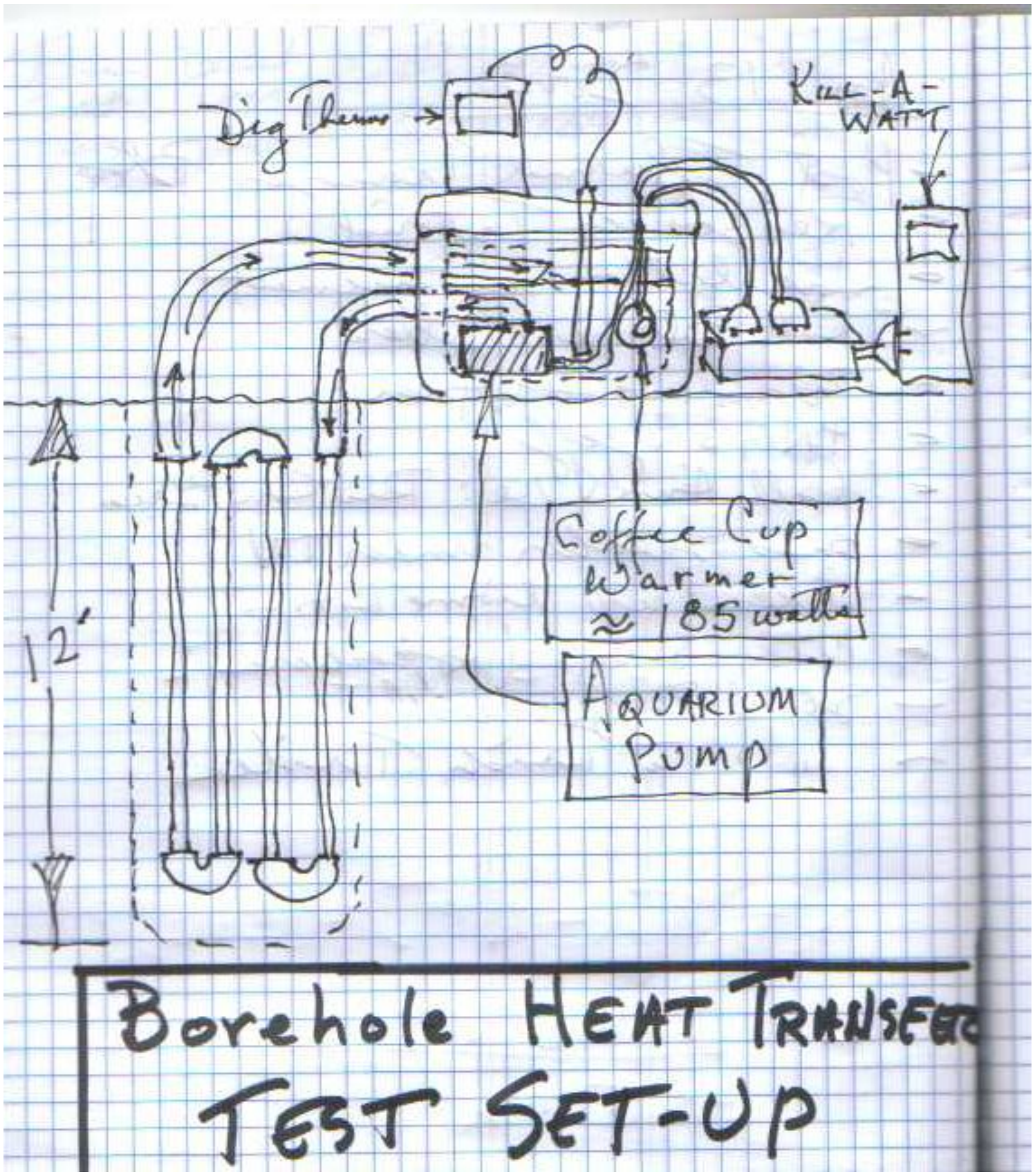
I had used a hand auger, meant for fence posts, and had dug to a depth of twelve feet in about 3 or 4 hours. I was going to fill the hole back in, but I decided to try to get some use out of the hole along the way. I buried a double loop of CPVC pipe I had laying about in the garage and attached some garden hose to the input an output of the loop. (see photo)

Then I filled the hole back up with the dirt that I had laboriously augered out and used water on the dirt as I went, so it would settle well.

I hadn't actually found the testing method document that I'm linking to above at the time I started testing, so I was just sort of making it up as I went along. I reasoned that if I introduced a known amount of heat-energy into the CPVC-loop, the ground would absorb the heat-energy at a rate that I suspected would decline. I further reasoned that if I monitored the temperature of the water, it would tell me something about the rate of absorption of heat by the ground. If the ground absorbed the heat at a high rate, the water temperature would be low, if it absorbed the heat energy at a lower rate, the water temperature would be higher.

So here's a sketch of my setup and a few photos:

Created By Green Energy Junkie



this shows the hole I'm doing the tests in. I used CPCV pipe (not recommended) with a double-loop (not much advantage over a single loop)...

I thought it would help to eliminate error if I used good pipe insulation on the hose. Bottom photo shows digital thermometer and kill-a-watt. A good analog thermometer would work just fine, but the digital is much easier to use. The kill-a-watt meter has a 'watt' function. It was set up to measure both the pump & the heater together, since they both give off heat. I found that the watts vary over time, so they need to be recorded at every chosen interval. It also has an elapsed-time function (called 'clock'), very handy.

this shows the set-up in the cooler box. I initially thought that it would be a good idea to put the coffee cup warmer inside of something so it wouldn't melt the foam box. I nixed this idea, and suspended the heater from the hose with a bread wrapper twist-tie.

So here's my test data & analysis...

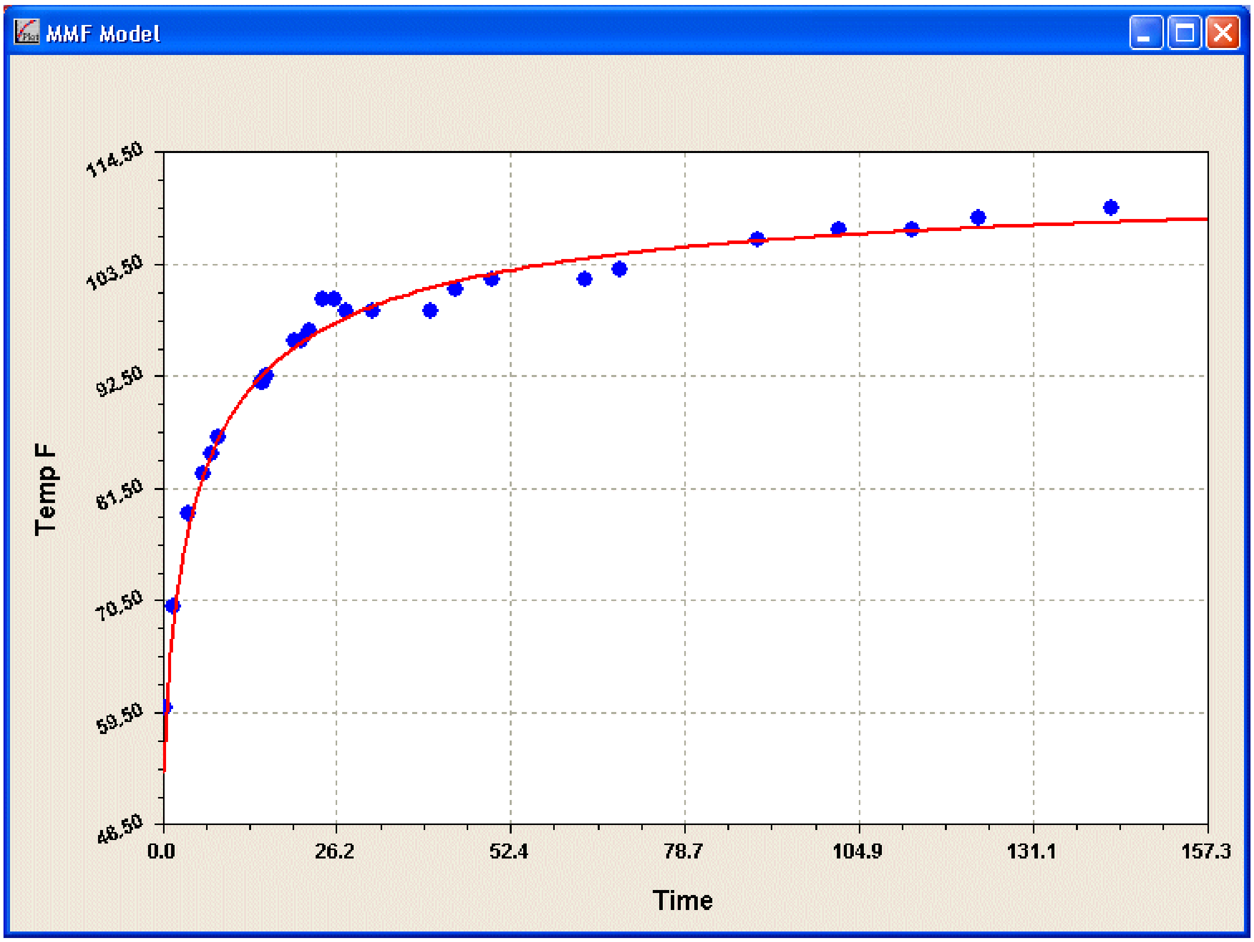
Time	Temp
0.00	54
0.133	57
0.167	57
0.50	60
1.733	70
4.00	79
6.25	83
7.50	85
8.433	86.5
14.833	92
15.25	92
15.517	92.5
19.883	96
21.00	96
22.083	97
24.03	100
25.82	100
27.65	99
31.67	99
40.317	99
44.23	101
49.60	102
63.65	102
68.93	103
89.55	106
102	107
113	107
123	108
143	109

Since I don't have an automatic data logger (yet) I logged all the data by hand. The time intervals were irregular but I think that it doesn't matter so much.

The first thing I did was to put the data into a curve analysis program. The program I found is a really great shareware program called CurveExpert for Windows available here: CurveExpert 1.3: Download

I've used this program for lots of things. There are even tutorial pages available, if you need.

At any rate, it was very useful to get well done graphs as the test progressed. The program does automatic curve fits and it was interesting to see that the program selected various curves before finally settling on an MMF type curve.



From CurveFit, it's even possible to get the equation of the curve that is the best fit and to project the curve forward in time. I was interesting to predict what the temperature would be at a particular time and to check the results as they came in.

But this wasn't really getting me what I needed, which was a quantified characteristic of the earth formation in my yard. This is where the document mentioned previously: TCTestingSum.pdf, came to the rescue.

I tried to follow the proceedure but wasn't able to get the same results as the author had. Either I was making a mistake, or I was using a version of Excel that was older and didn't have the exact feature he was using. But I devised a work-around and got reasonable results.

Here was my proceedure:

1) Start Excel
2) Open the data from a tab-delimited text file. This just means that the data is written in a test file and you hit the 'tab' key after the Time data, but before the Temp data. If the tab could print like this: <tab>, your data would look like this:

...
0.00<tab>54
0.133<tab>57
0.167<tab>57
...

Anyway this is a standard text format that Excel understands.

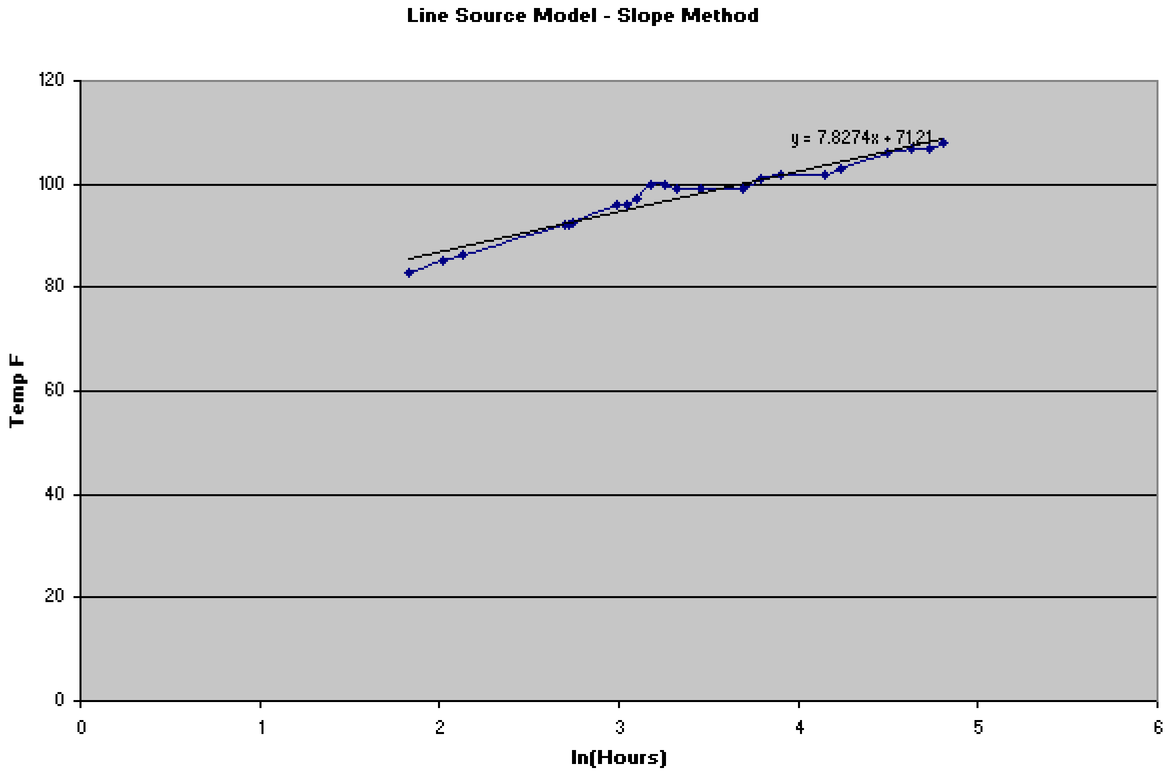
...of course you could just enter the data straight away into Excel and I could save myself some time & typing.

If you graph the data I have included, it would look like this:

See picture

Looks similar to the graph from CurveExpert.

At this point, the author of TCTestingSum.pdf was able to do a right-click on the graph curve that Excel made. Then he was able to choose "Add Trendline" and then a Logarythmic trendline, and the result, as illustrated, was a linear graph. I was not able to get these results, certainly not the graph as illustrated. So my modification to the process was to return to the spreadsheet, 'Insert' a column between the Time data and the Temp data. Then I wrote a simple formula (=ln(A1)) that took the natural log of the data in the time cell. I copied this formula down to the rest of the data cells. Then I made another graph of these data columns, "ln(Time)" and "Temp". At this point, I got a graph that resembled the illustrated results.



I then did the right-click and 'add trendline' this time I chose "Linear", since the natural log function had essentially linearized the graph. This did give me a formula with slope. Then I was able to use the rest of the proceedure as described. This all gave me a "k" value of 0.569464441. I was in turn able to use this value to calculate the total length of borehole, which would yield 12,000 BTU/hr. This calculated borehole length came to 214.23 feet. Which is reasonable, as I hear from local installers that they estimate that 12,000 BTU/hr (AKA: one Ton) borehole length to be in the range of 175 to 225 feet.

Some improvements:
* Get a real data logger
* Use the actual type and configuration of Polyethylene pipe I plan to use in the actual installation.
* Use a borehole that is closer to the actual location of the installation (the test borehole was within three feet of my basement, so error is to be expected)
* use the type of grout I plan to use. I'm currently planning to use "mix-111", more information available here:
[Information Bridge: DOE Scientific and Technical Information - Sponsored by OSTI]()

P.S.: For those who want to know more about the topic of borehole testing, I have located what might be the definitive paper on the subject:

http://epubl.luth.se/1402-1544/2002/...DT-0239-SE.pdf

P.P.S.: Here is a link to a report from a professionally done borehole test. Note the unusually high results and the speculation as to why such unusual results were obtained.: http://www.tva.gov/commercial/TCStud...iles/Se-02.pdf

...and another done in Alabama in 2000. These are more typical results. http://www.tva.gov/commercial/TCStud...iles/Jo-18.pdf

...and yet another done in Illinois in 2008. http://www.midwestsustainable.com/Co...%20Example.pdf

Selecting A Likely Candidate For Building A Heat Pump

So if the Guide is called "how to make a heat pump out of junk", I guess one of the first secrets is how to tell that the hardware you have is not really junk after all.

In this section, I'm going to describe finding an Air Conditioner Unit as a candidate for re-purposing. De-Humidifiers also make good candidates, maybe even better, but there are many more AC units in Goodwill, junk stores and garage sales.

Although you can get by without one, a device that will measure watts in realtime can be a very useful tool, not only for selecting but also for subsequent testing and evaluation. I use a model called a Kill-A-Watt link here: [http://www.p3international.com/produ...P4400-CE.html]. I actually have two and I use them all the time.

The popular misconception about non-functioning or poorly functioning AC units it that "the refrigerant leaked out". Compared to other problems, this is actually pretty unusual. The most common problem is that the coils have become blocked by debris.

So first, we need to run it.

Plug the unit in. If you have one, plug the unit in to a watt meter and the watt meter into an outlet.

Turn the unit to 'fan only' or 'cool off' or what ever it takes to just run the fan. Let it run and note the reading on the watt meter. It should be somewhere in the 30 to 80 watt range. If it is drawing more than 80 watts, then compressor is on. Turn off the compressor. Let the unit run for five minutes and feel (or measure) the air coming out. This will be our baseline temperature.

AC_fan-only

After five minutes or so, turn the unit to Maximum cool and the fan to high. Let it run for 5 to 10 minutes.

CASE #1 - Watt meter reads 300 to 1500 watts, the unit is blowing copious amounts of cold air out the front (obviously cooler than our baseline temperature). When you feel the rear coils, they should feel a bit warm to the touch.

AC_fan+compressor

If this is the case, you obviously have a proven winner.

CASE #2 - Watt meter reads reads between 300 and 1500 watts, the unit is not cooling very well. The rear coils feel warm-to-hot. The front coils feel cold.

Possible causes:

a) Blocked Air Flow - This is very common. The filter in the front or the coils in the front or back of the unit are blocked. This may be why the unit was tossed. If you feel the coils in the front they should feel cold, also if you feel the coils in the back, they should feel warm. If the coils or air-filter are clogged it's simple to fix with a really strong vacuum cleaner, but for our heat pump purposes, you might not use the refrigerant-to-air coils at all. Liquid-to-liquid heat exchangers are much more efficient and open up a very interesting world of experimental possibilities. In the coming posts, I will show you how to buy or make liquid-to-liquid heat exchangers.

b) The refrigerant has leaked. This is actually pretty unusual. If your unit is drawing more than 300 watts, and no cooling is happening, don't consider this unit at all. If refrigerant can get out, water can get in. Water in any amount, in the refrigerant system is bad for heat pumps.

CASE #3 - Watt meter reads 30 to 80 watts during the whole test.

This means your compressor never came on. Possible problems:

a) The compressor is dead. Compressors are well-built, hermetically sealed and tested before they ever leave the factory. This would be very unlikely to be the case.

b) The compressor starting capacitor is dead. The compressor starting cap is pretty darn reliable. This is also an unlikely case.

c) The compressor thermal safety switch has failed. These are reliable, not so likely to fail.

d) The switch on the front of the unit, or it's attached thermal sensor is bad. These can be the problem more likely than the above problems. But if these are the problem, it makes subsequent testing difficult.

e) The temperature where the AC unit is being tested is too low for the cooling cycle to start. This is can be very likely. Most of the units I have looked at need to be warmer than about 65-70 degrees F to begin to work, even at Maximum cool. You may have a winner on your hands...maybe.

So, if you can't verify that the compressor is actually working, it's really a crap-shoot. If you can get the unit for free or really, really cheap ($5), it might be worth it, but no matter how cheap, remember if it doesn't work, you still have to dispose of the carcass. Probably better to keep looking...

Other things to consider:

Look for the refrigeration identification tag. It will tell you some things like:

* Cooling capacity - This is a sales figure. It may be accurate, or it may be exaggerated. This was what was found under 'lab conditions', wherever or whatever that is.

* Input - This is about the maximum that the compressor and the fan will draw.

* Refrigerant Pressures - Write this down, you may need this info later.

* Refrigerant Type - This is the refrigerant that the unit was designed to use.

Freon - Usually R-22 & R-12. They worked great except that they destroy the ozone layer and cause global warming. A real problem. These are very expensive to obtain and in some cases illegal if you don't have a HVAC license certificate.

It is interesting to note that German Children seem prefer using Propane (AKA: R-290, Barbecue Gas, etc) because it is not damaging to the ozone layer and has zero global warming potential, and is incredibly cheap, and requires no license to obtain. It also works well with compressors designed for R-12 & R-22, as it uses the same type of lubricant (mineral oil type). It also seems to be similar enough to R-22 that it can be use without significant modification to the metering devices (more on that later). If I understand correctly, R-290 is being used as an automotive refrigerant in Australia. It is very flammable and produces water vapor and carbon dioxide (CO_2) in the process.

R-134a - Currently in use. Can be obtained in auto parts store. It does not destroy the ozone layer but does cause global warming. It will be restricted and then phased out. Compressors that use R134a will not be compatible with Freons, as the compressor oil is of a different base and does not play well with mineral oil compressor lubricants or the refrigerants that use these lubricants (R-22 or R-12 and R-290). I have heard of people having success by completely replacing the lubricant with mineral oil compressor lubricant. I have not tried this. Use of this refrigerant is reported to cause cancer of the testicles in lab rats. Under certain conditions, R-134a can burn and produces deadly gasses in the process.

Regarding the size of the compressor, there's a saying that a cowboy can't have too much money, too fast a horse, or too many women. Well, what works for cowboys doesn't really work for heat pumps. if you have a large compressor, you pay more for it with every revolution. The trick is to figure the maximum BTUs or watts you will need, and design a little bit smaller. Plan to use a supplimental energy source to fill in during extreme conditions.

So I have found smaller units to be the most interesting. I have a couple of bigger compressors (about 12,000 BTU) in the cellar for future experiments, but it's the smaller ones that really fascinate me now (small house heating, water pre-heating, high efficiency refrigeration, domestic water heat recovery, etc.)

The AC unit that is in these pictures works perfectly, looks brand new, is the right size and had the fabric filter clogged with cat hair. It cost $25.

Remember, don't open the refrigerant system until you're all prepared and ready to braze it back up. We have a way to go yet.

How Refrigeration Works...

Before we open up our Air Conditioner, it would be a good idea to consider how the thing works, so that we will have some appreciation for the stuff we're going to be looking at and in some cases modifying.

I have talked to lots of people, modern people, who just can't understand why I think I can use a refrigeration compressor (actually Air Conditioner compressor), which they associate with cold, and to bury pipes in the ground, which they also associate with cold, and reasonably expect that this procedure will result in making my house warm. I've tried to use refrigerators as an example, which they associate with cold, to explain the process, and I usually get to see people with pitying eyes stare at me, wondering how an otherwise reasonable person could be so misled.

But I'll try again here...

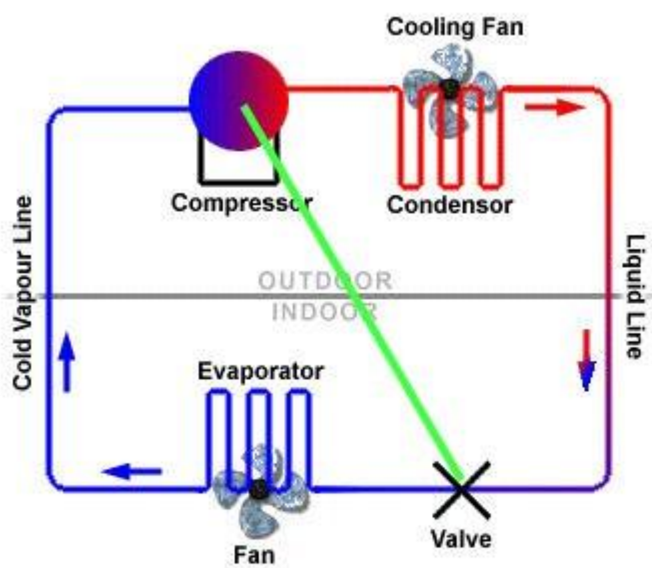
First off, what is heat?

We have an intuitive notion that heat is what we feel when we touch something that is warmer than our hand. And the opposite, cold is what we feel when we touch something that is less warm than our hand.

If we look really deeply into the question of what heat is, we will find out that heat is actually a manifestation of energetic movement of molecules. The greater the movement, the greater the heat. But something what might feel cold to us, like cold water, in fact has this energetic molecular movement that results in heat. It may have less energetic movement than warm water, but it still has energetic movement.

In fact, any material will have this energetic movement that we will call heat until the very cold temperature of −459.67°F. SO compared to that the temperature of the ground is pretty warm.

Let's look at this refrigeration diagram:



This is a simplified diagram of the components in the refrigeration cycle of our air conditioner. I have taken the liberty of adding the light green line to the diagram from the compressor across to the "valve" (AKA: metering device, expansion valve, capillary tubing, etc.). This green line marks the boundary between the high pressure side (AKA: high side, pressure side, hot side) which is on the right side of our diagram, and the low pressure side (AKA: low side, suction side, cold side) which is on the left side of our diagram.

This whole refrigerant circuit is hermetically sealed from atmospheric pressure, it is in it's own special refrigeration world, there's no water in there, there's no dirt in there, just refrigerant and some lubricant. Before we power up the compressor, the pressure of the refrigerant gas/liquid on both sides of the diagram is under greater than atmospheric pressure (probably in the range of 50 to 100 psi), but it is equalized on both sides. Neither side is hotter or colder than the other.

When we put power to the unit, we intentionally create an imbalance and we exploit the changes that result from this imbalance.

There may be a bit of a time delay, but very soon, the compressor starts working and it begins discharging refrigerant gasses out of the compressor and sending them through the high-pressure side tubing. They travel through this tubing until they get to the "valve" where their progress is slowed almost to a standstill. But the compressor continues pumping away and the gasses back up and the pressure increases and so does the heat of the gases and at some point, the gasses are under so much pressure that they almost begin to turn into a liquid, a hot liquid. This hot, highly pressurized gas then flows through an assembly which allows for the removal of some of the heat. This assembly is called the condenser. When enough heat is removed, the hot gasses in the condenser actually do turn into liquid, and in so doing they yield up an accellerated amount of heat. (* This gives us a thermal imbalance that we can exploit to make our heat pump. This thermal imbalance is where the heat that we desire to heat our house or our water is extracted. But where does it come from? Read on...) The hot liquid then moves along to the expansion valve.

The expansion valve in small air conditioners usually takes the form of what is known as a 'capillary tube', or 'cap tube' in the trade. This cap tube uses the friction created by both a very small diameter, and a relatively long length to consistently restrain the flow of liquid refrigerant in the circuit. The cap tube is reliable, fairly consistent and cheap. The cap-tube is designed to work with our compressor, so we'll want to salvage it when we begin major surgery.

Loook at the second picture:

Cap Tube

So the liquid flows in a restrained manner through the cap tube, which may be 4 to 8 leet in length, all coiled up, inside our air conditioner. Then something strange and wonderful happens...

While the compressor has been feverishly creating a high-pressure condition on the right side of our diagram, it has also been feverishly creating a low-pressure condition on the other side of the diagram.

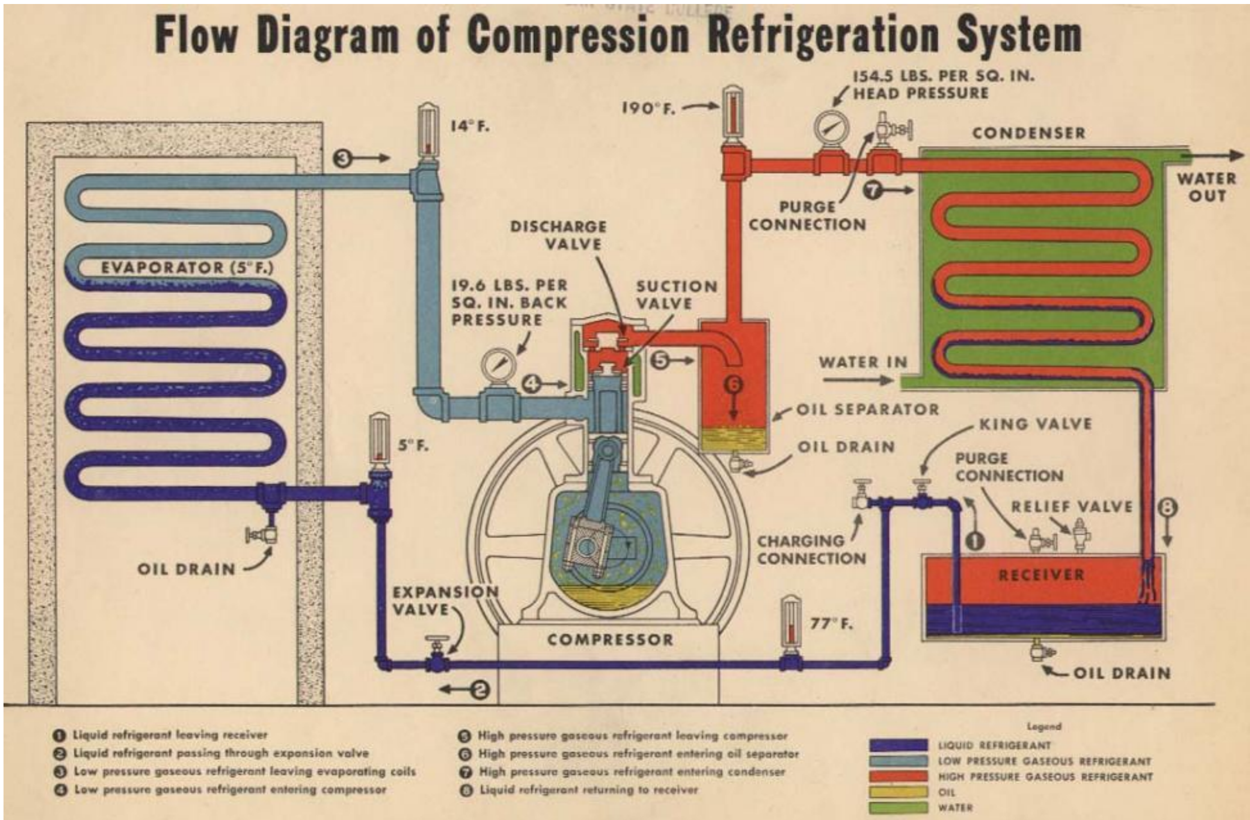
As the refrigerant travels through the cap tube, at some point very near the exit of the cap tube (less than an inch) it enters the low pressure created by the compressor. When this liquid enters the low pressure area, the imbalance of pressures force the liquid to instantly flash into vapor. (* This instantaneous flashing into vapor causes an instantaneous drop of temperature. Here we have another thermal imbalance which we will also exploit in our heat pump. This extraordinary imbalance, cold in this case creates a thermal "vacuum" into which heat from surrounding earth or water will flow. *)

Look at the third picture:

Frost Formation

Created By Green Energy Junkie

I'm also adding another diagram of a refrigeration circuit. It's really a great illustration, and you should be able now to understand just what's going on in this picture.



Opening the Case

So now we're going to open up the case, but we are not yet going to open up the refrigerant system. Safety first, make sure you have the Unit unplugged. Locate the plug before you start using the screw-driver.

Unplugged

(NOTE: when I take something apart anymore, I keep my digi-camera close at hand and take photos at every step. This way if I forget exactly how it goes back together, I can refer to my photos.)

Most AC units are built very much alike. If you have a different model, even a different brand, you should be able to follow right along with the text & photos here.

SAFETY NOTE

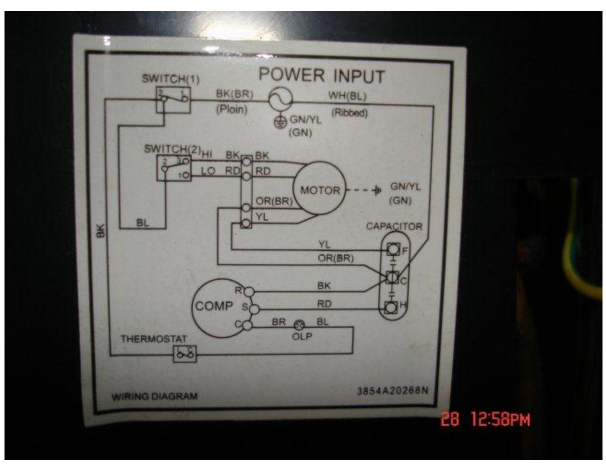
Capacitors of that size can store lethal voltages even when the unit is unplugged. So be careful!

Remove all of the sheet metal screws that look like they might be holding the beast together. When you think you have them all, give the sheet metal & plastic case pieces some gentle tugs to take it off. You might want to re-use all of or maybe part of the case, so treat the sheet metal with care and save the screws all together where you won't lose anything.

Here's what I ended up with:

Naked AC Unit

one of the first things we should look for is the schematic. It will be on a piece of paper stuck inside, or glued to a panel in side, but they all have them and they have useful information.



schematic

A couple of things to note in the schematic... On my schematic, in the lower central area of this schematic, coming off of the BR wire of the compressor, there's a symbol labeled "OLP". This indicates the Over-Load Protector, and is a round bi-metallic module that is under the plastic cover on top of the compressor. It serves the purpose of preventing the compressor from overheating. If a maximum temperature threshold is reached, a bi-metallic
spring will interrupt the flow of current to the compressor. We'll look at it later. Also of interest is the "capacitor". symbol on the lower right of the schematic. The compressor and fan motor each use a starting capacitor to nudge them into starting. In most of the air conditioners I have seen, there is only one capacitor case, with two capacitors inside, a smaller one for the fan and a larger one for the compressor. If we decide that we don't want to use the fan, we can still use the same capacitor, and just ignore the fan side.

Next is the compressor, it's the main reason I bought this AC unit. It accounts for most of the weight and cost of any air conditioner.

Compressor Side

There are two copper tubes that come from the compressor. One comes out of the top. This is the high pressure discharge from the compressor. the other tube usually goes in the side, near the bottom of the compressor. This is the low pressure (AKA: suction side) tube. We can expect that the high pressure side will become warm when the compressor is running, we can also expect that the low pressure side will be cooler to the touch, when running.

While I am looking around the compressor, I also see a coil of thin copper tubing. This is called the "cap tube", short for capillary tube, which is the air conditioner's refrigerant metering device.

Cap Tube

This cap tube is carefully sized (length and diameter) to the compressor and the refrigerant type. It is possible to size my own cap tube, but if I'm careful, I will be able to use this one. As previously stated, R-22 has characteristics that are very similar to R-290.

Also of interest, but perhaps a little hard to see, is that the compressor is sitting loosely on little rubber vibration absorbers. These are also matched to the compressor, so if possible I will keep them too.

Let's take a look at the top of the compressor...

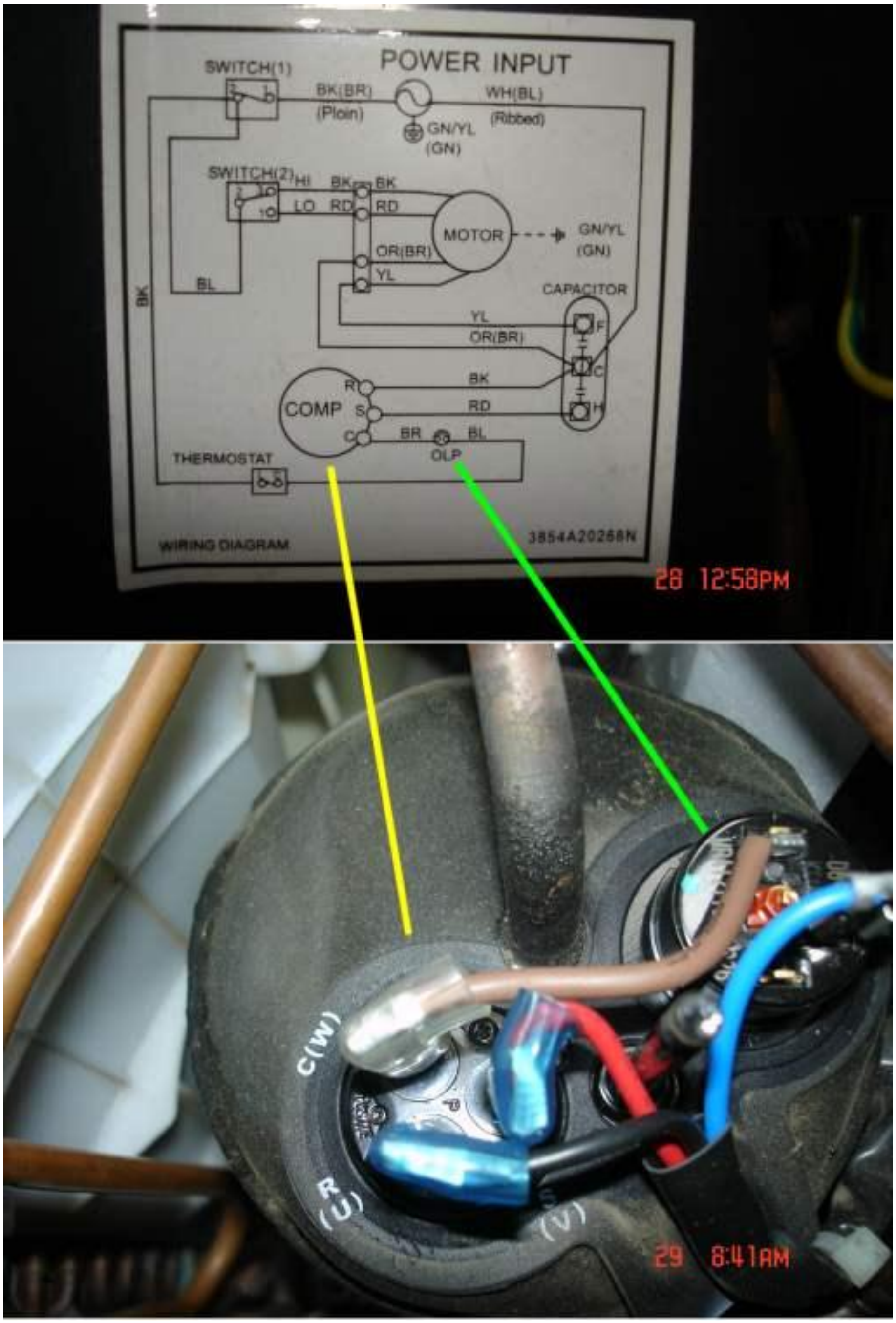
Compressor Capped

There's a plastic cap, held in place by a single nut. the power wires and the OLP (over load protector) are under this. Take a moment to notice the letters printed at the edge of the cap, we'll see them again. If the AC unit is unplugged, let's remove the nut for a quick look inside.

Compressor Uncapped

Here we see various colored wires that power the compressor. We also see the OLP device which will press against the top of the compressor, when the cap & nut are in place.

If we compare what we are looking at to the schemetic, we will see this...



Schematic & Compressor

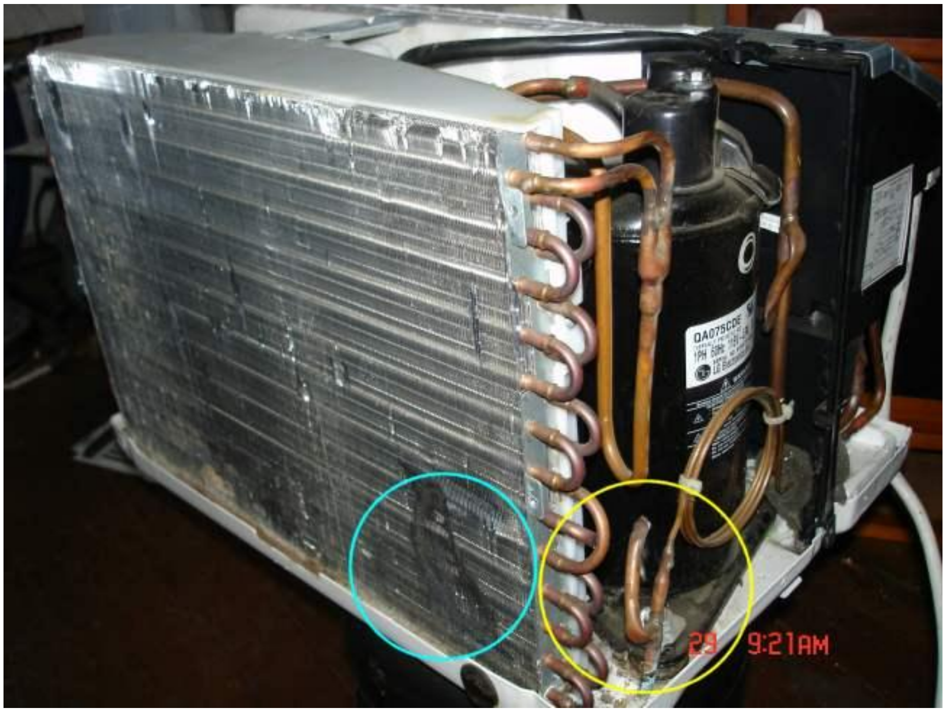
I've drawn in a light green line between the OLP on the schematic and the actual OLP device.

I have also drawn in a yellow line between schematic's compressor connections and the real thing. Take a few moments to familiarize yourself with the connections, the wire colors, the letter symbols on the schematic and the letter symbols on the actual compressor. Do they all agree?

Now put the cap and the little washer and the nut back on the compressor. The nut should be snug but not really tight.

Next, let's look at the rear side of the AC unit. This is the side that will be outside the window. On a day when the AC is running, this radiator will be exhausting the hot air from the room (and the heat generated by the compressor). The name of this radiator (AKA: air-to-air heat exchanger) is the 'condenser coil'.

I have drawn a light-blue circle to indicate and area where the aluminum fins got 'mooshed'. If I want to use this condenser, I can straighten out the fins by hand. Small combs are available to help with this job. If the air is not able to flow freely past this part of the condenser, it can't dump it's heat.



Condenser

I have also drawn in a yellow circle around another detail... This piece of bent-over tubing is where the refrigerant was put into the unit at the factory. If this looks a bit funky, it's because in mass production, every effort is made to shave cost from the millions of units that are produced. If a real service valve was here, the price to make this AC unit would be about a dollar more. When millions of units are produced, it adds up to real money. If I decide to build a heat pumpout of this unit, I will need to put in a real service valve (AKA: Schrader Valve) here, and I will put in another one on the 'low-side' of the compressor.

Schrader valve

The Schrader valve comes in various configurations, the most common has the same thread as a 1/4 inch flare fitting, and the valve core is an automobile valve-stem core. be sure that when you braze on a Shrader valve, that you first remove the valve core before you apply heat, and wait until the brazed area is cool to the touch to re-install the valve core, else the valve core seals will melt, stink and fail to ever work again, as I found out.

Lets take a closer look at the flow of refrigerant...

Compressor To Condenser

...here we see the discharge tube coming from the top of the compressor and down through a 'U-shaped' tube, then splitting into two paths and entering into the condenser coil. I have drawn the directional arrow in RED to indicate that the refrigerant is hot at this point, both because it has been compressed, and because it has picked up heat from the compressor. The U-shaped tube is there partly to help spread out the vibrational stress over a longer distance, to prevent pre-mature failure of the copper tube. The splitting of the refrigerant paths is to raise the efficiency of the condenser coil to expose more high-pressure gas to more air-cooled copper tubing.

At the bottom of the condenser coil, the two refrigerant paths converge into one path and enter the cap tube. I have drawn the directional arrow in MAGENTA to indicate that the trip through the condenser has removed heat from the refrigerant.

Then the refrigerant flows through the cap-tube and then enters the 'suction side' (AKA: low-side) of the refrigeration cycle.

Cap Tube to Evaporator

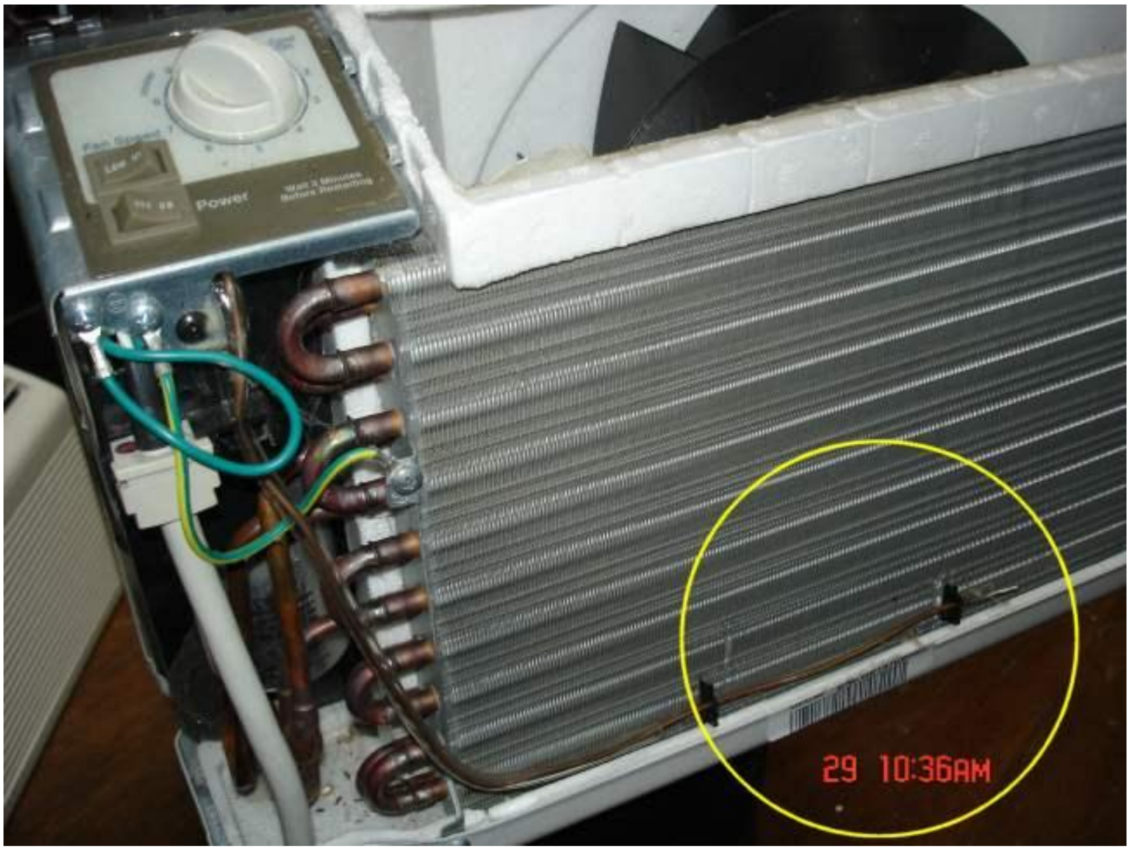
I have shown the path of the refrigerant through the cap-tube in MAGENTA. I have drawn the circle and arrow in BLUE because this is the point of expansion of the refrigerant, this is where the refrigerant flashes from warmish liquid to very cold gas. When we run the AC unit, we can expect to find frost forming at this point first, and then spread along the tube tward the evaporator tube.

Here's another detail of the tubing near the condenser:

I have drawn the flow arrow to the condenser in BLUE to indicate that it is really cold, and the flow arrow from the condenser in LIGHT BLUE to indicate that some of the cold has been lost, actually heat has been gained.

Also note in the background of this picture, the silver cylinder. This is the starting cap for both the fan and the compressor.

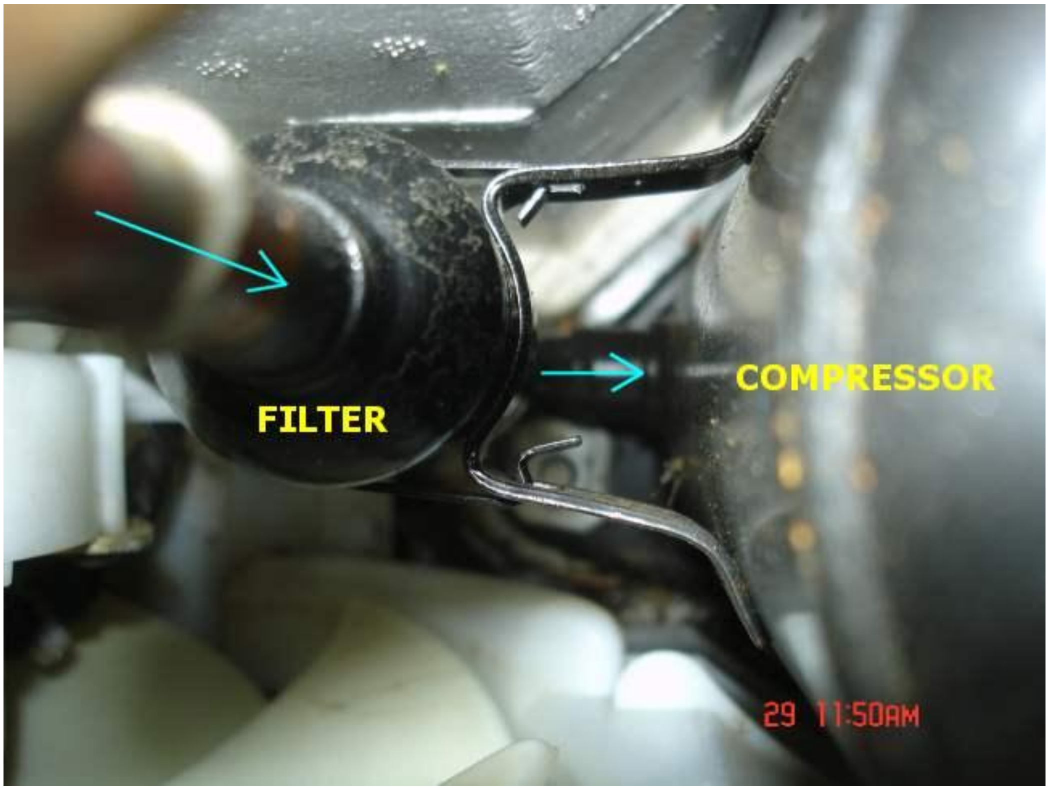
Next is a full shot of the condenser.



Condenser & Temp Sensor

Note the temperature sensor at the bottom of the evaporator coil. It is there to sense the temperature of the exiting room-air and also to sense if the evaporator gets really frosty. It will shut down the AC unit to allow the frost to melt. Then after a few minutes (about 5 minutes) the unit will start up again. If we are clever, we might be able to reuse this sensor for our newly re-purposed machine.

Next photo is looking down next to the top of the compressor and shows the return of the refrigerant to the compressor.



Back To The Compressor

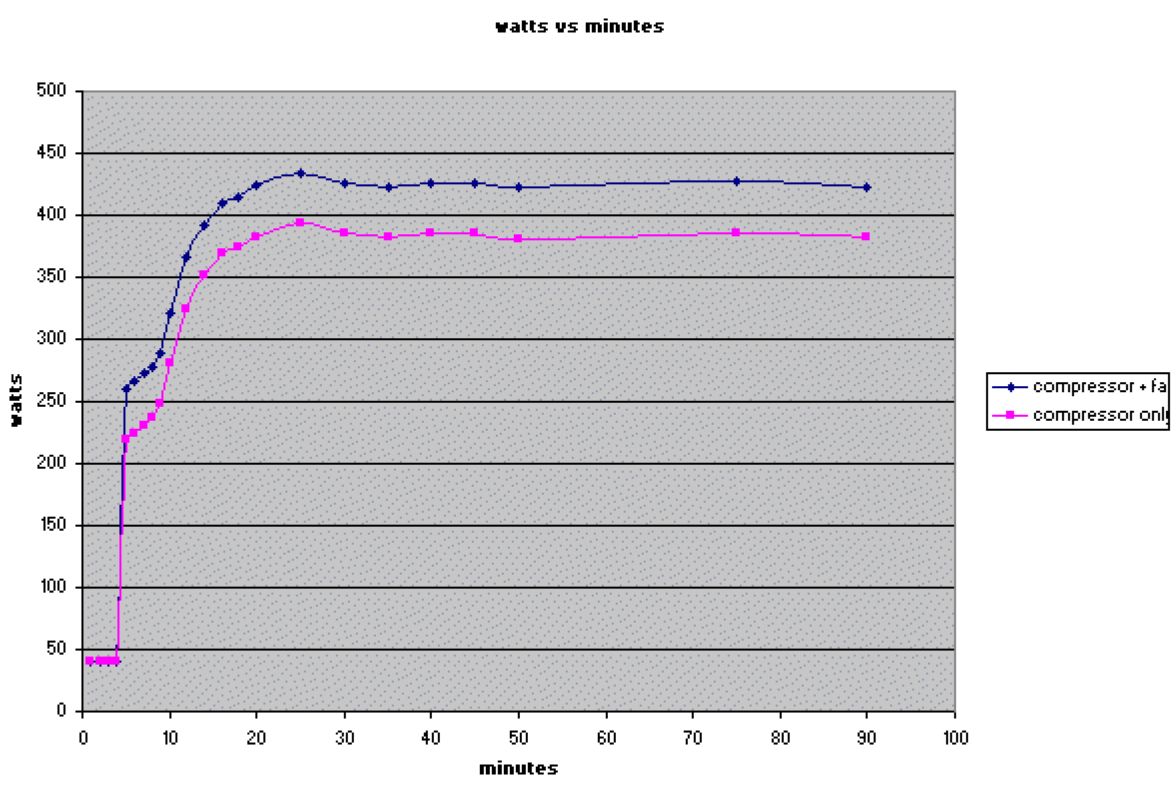
The refrigerant has lost some of it's cold to (gained some heat from) the room air during it's trip through the evaporator coil, but after it passes through the filter (which also contains desiccant to remove any water that may have been inside at the time of manufacture), and enters the compressor, it is definitely cooler than the compressor. The designers count on this to help keep the compressor cool.

We look under the hood to see what's going on... (conclusion)

Let's take advantage of the fact that the cover is off and watch what the unit does under power...

Make sure that the cover is back on the compressor, and that no screwdrivers or wrenches are in or on the AC unit. If you have a watt-meter, this might be a useful time to measure the power consumption of the unit.

I let mine run for a couple of hours and here's what it looks like.



Watts vs Minutes

If we look at the evaporator end of the cap-tube, we should see frost forming.

Early Frost

After it has run awhile, the compressor's heat begins to build and we see that the frost on the evaporator line has decreases a bit.

Later Frost

I have included here an interesting chart that shows various refrigerants, and when they were discovered.

TABLE 1.1
Introduction of Refrigerants

Year	Refrigerant	Chemical Makeup, Formula
1830s	Caoutchoucine	Distillate of india rubber
		$CH_3–CH_2–O–CH_2–CH_3$
1840s	Methyl ether (RE170)	$CH_3–O–CH_3$
1850	Water/sulfuric acid	H_20/H_2SO_4
1856	Ethyl alcohol	$CH_3–CH_2–OH$
1859	Ammonia/water	NH_3/H_20
1866	Chymogene	Petrol ether and naphtha (hydrocarbons)
	Carbon dioxide	CO_2
1860s	Ammonia (R717)	$NH_3CH_3(NH_2)$
	Methyl amine (R630)	$CH_3–CH_2(NH_2)$
	Ethyl amine (R631)	
1870	Methyl formate (R611)	$HCOOCH_3$
1875	Sulfur dioxide (R764)	SO_2
1878	Methyl chloride (R40)	CH_3CL
1870s	Ethyl chloride (R160)	$CH_3–CH_2CL$
1891	Blends of sulfuric acid with hydrocarbons	H_2SO_4, C_4H_{10}, C_5H_{12}, $(CH_3)_2CH–CH_3$
1900s	Ethyl bromide (R160B1)	$CH_3–CH_2Br$
1912	Carbon tetrachloride	CCl_4
	Water vapor (R718)	H_2O
1920s	Isobutane (R600a)	$(CH_3)_2CH–CH_3$
	Propane (R290)	$CH_3–CH_2–CH_3$
1922	Dielene (R1130[a])	$CHCl{=}CHCl$
1923	Gasoline	Hydrocarbons
1925	Trielene (R1120)	$CHCl{=}CCl_2$
1926	Methylene chloride (R30)	CH_2Cl_2
1931	R12	CF_2Cl_2
1932	R11	$CFCl_3$
1960s	R22	CF_2ClH
1980s	R123	CF_3CCl_2H
1980s	R124	CF_3CFClH
1980s	R125	CF_3CF_2H
1990s	R134a	CF_3CFH_2
1990s	R407C	R32/R125/R134a 23/25/52 wt.%
1990s	R410A	R32/R125 50/50 wt.%
1990s	R404A	R125/R143a/R134a 44/52/4 wt.%

There's more to learn about the innards of an AC unit, but this should do it for now.

This is the conclusion of "We look under the hood to see what's going on".

I hope this has been useful for you, and has not only given you a bit of knowledge but has fortified your gumption to continue on with some interesting and useful AC hacking.

What Can We Do With This Thing?

OK, so by now we have some idea how refrigeration works, we have located and purchased an AC unit, we have taken the cover off and inspected it to familiarize ourselves with it.

The next step is to consider what we might do with it. If we do this right, we should get a COP of 2 to 5. Since COP is energy in divided by energy out, it means that for every kilowatt-hr we put in, we can get out 2 to 5 kilowatt!

Or to look at this in BTU terms, we multiply the watts by 3.412 to get BTUs. This means that every kilowatt will give us between 6824 BTUs (1000 x 3.412 x 2) to 17060 BTU's (1000 x 3.412 x 5). This really makes this an interesting project.

So here are some possible considerations:

Hack 0:
No mods at all. Just stick it in a window and use it as it was intended to be used. After all, summer is coming on.

Hack 1:
Turn it around backwards, modify the controls a bit and use it as an air-source, window-mounted heat pump.

Hack 2:
Keep the both the air-to-air condenser coil and the air-to-air evaporator coil, but re-configure them so that they could be used in a home ventilating system, to remove heat from the stale exhaust air (using the evaporator coil), and to warm fresh, incoming air (using the condenser coil).

Hack 3:
Keep the evaporator coil but remove the condenser coil and in it's place, use a refrigerant-to-water heat

exchanger. This would give us a device that would remove heat from the air (and also de-humidify the air at the same time) and put the heat into water to be used somehow. One possibility would be a water pre-heater similar to these units:

Save Energy Maine - Energy Efficient Heat Pumps. Save Money on Your Heating Bills

Another possibility is that we could run the water through a ground loop, which would greatly increase the efficiency of our AC unit.

Hack 4:
Keep the condenser coil but remove the evaporator coil and in it's place, use a refrigerant-to-water heat exchanger. This would give us a unit that would remove heat from a water filled ground-loop, and bring it indoors for house heat.

We could also use the water loop for a high efficiency water-jacketed refrigerator.

Hack 5:
Replace both of the air-to-air coils, instead using water-to-water. This would give us a small, cheap water-in-water-out heat pump.

For the refrigerant-to-water heat exchangers, they can get pretty expensive. However, I have found that if you shop really hard, you can get good deals on ebay:

Here:
heat exchanger, Business Industrial, eBay Motors items on eBay.com

And here:
plate heat exchanger, Home Garden, Business Industrial items on eBay.com

The size we'll need is pretty small. For instance, if we're using a 400 watt compressor, and estimate our performance to be COP=2 to COP=5, the heat exchanger's capacity will be between 2730 and 6824 BTU. If we use a 1000 watt compressor, the heat exchanger's capacity will be between 6824 and 17060 BTU.

So look hard, there are some great bargains to be had.

Later I'll show you how to make a heat exchanger, but some of these on ebay are so good and so cheap, that it may be cheaper to buy.

I've been seriously scouring the Internet for information on selecting a brazed plate heat exchanger for hacking purposes.

I have learned that brazed plate heat exchangers were designed by the Germans, and are being made by several companies, of essentially the same materials, and have essentially the same performance.

So I was able to dig up a selection program here:

http://www.flatplate.com/downloads/f...ateSELECTw.exe

...this one doesn't seem to be supported anymore, but it is for the same product line as the newer one. This one is down-loadable, which I like because you can try various scenarios quickly. Also note that this program has been picked up by Internet Archive "wayback Machine"(www.archive.org), so it should be available for a long time.

The newer one is available here:

Login

...you'll need to register for this one, but there doesn't seem to be any 'fact checking' in the registration.

I have also Googled my tail off hunting down <"brazed plate" refrigeration selection> documents, of which I found quite a few. Mind you, that when you are seeking this information you need to look for info for "refrigeration" and not water-to-water.

Here is a doc:

http://www.eptec.no/images/Marketing...20NA08583B.pdf

...this should get you pretty close to the size you want to use.

I noticed that the selection program seemed to be selecting larger heat exchangers than the product literature suggested.

Since the product literature came closer to my experience so far, I prefer it.

So we need to get used to the idea that we can think in terms of BTU/hr and also watts.

For instance, to convert 1000 watts to BTU/hr, we multiply by 3.412:

1000 x 3.412 = 3412 BTU/hr

To convert 8000 BTU/hr to watts, divide by 3.412:

8000 / 3.412 = 2345 watts

So for instance, if you have a compressor that draws about 800 watts, as measured by a watt meter (kill-a-watt), you don't choose a heat exchanger that has an 800 watt capacity (2729.6 BTU/hr). Instead you look at how much heat it can move, which can be 5 times the watts it draws. (Amazing, yes?)

So for instance:

800 x 3.412 x 5 = 13648 BTU/hr

If you are looking on ebay for an exchanger, they almost always give you heat transfer numbers that are either for water-to-water purposes like solar or hydronic use, or else they are completely 'plucked from the sky'.

My advice is to really study the brazed-plate refrigeration selection charts, as many as you can find.

I did that, and noted what the brazed-plate refrigeration heat transfer was for several sizes of product from several manufacturers. Then I came up with a figure for the heat transfer divided by the total area of the various units. I came up with different numbers, but they were in the range of 5000 BTU/square foot.

You should do your own research on this since it's your money you're going to spend.

So, having done all that, I came up with a small brazed plate unit that is about 7.5 inches by 2.88 inches by 10 plates thick.

From my previous post:
>>
So the formula might look something like:

Heat = ((width) x (length) x (# of plates - 2)) x 5000

...where width & length are expressed in feet
>>

width = 2.88 inches = 0.24 ft
length = 7.5 inches = 0.625 ft

so:

Heat (exchanger) = (0.24) x (0.625) x (10 -2) x 5000 = 1.25 x 5000 = 6000 BTU/hr

Next, I'll check to see what my compressor can move by calculating the heat I anticipate that I will be able to move with my compressor:

Watts I measured when I ran my compressor = 380

COP I can expect = 5

Heat (compressor) = (380) x (3.412) x (5) = 6482.8 BTU/hr

CONCLUSION: According to these calculations, the compressor can move more heat that my heat exchanger can. Normally this is NOT such a good situation. In most cases, I would prefer that my exchangers exceed my compressor, for greatest efficiency. However, I built a heat exchanger last summer with exchangers that were twice the size I am now using, with a compressor that was just about equal in size to this 380 watt unit. I ran great, but I never knew if my guesswork put me right on the edge of good performance, or if I had a wide margin or a very wide margin. So I've decided to go ahead and build this unit to see if my performance is reduced somewhat.

So, I'm fact-checking my calculations

Can't wait to start cutting & brazing...

Polyethylene Fusion Heater...

My fusion heater is coming along also.

I used the following thrift-store, garage sale & junk bin items in making it:

* 300 watt heating element from mini-sandwich maker

* Teflon coated aluminum from heavy aluminum skillet

* Heat controller from unrelated skillet

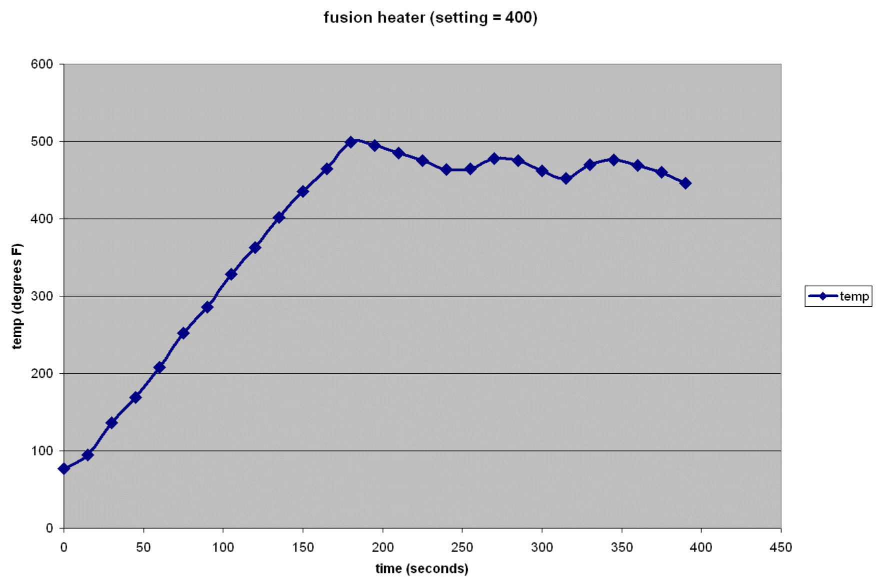
Here are some pix:

This shows the plates milled out to accomodate the heater element. I also milled a plate on my drill-press using a quarter inch drill-bit. It looked like hell but worked. Howard has a NC shop and did a perfect job in just a few minutes (shown). Not shown in this pic is a channel I drilled out to recieve the temperature controller probe.

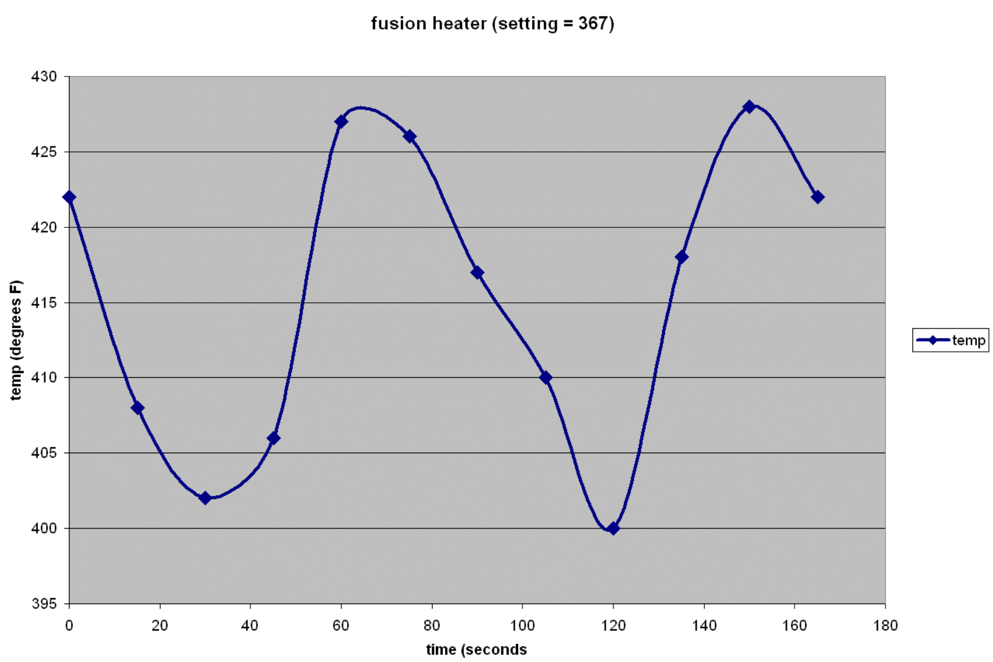
This shows the front of the unit. I still need to put a cover over the deadly voltage parts.

Created By Green Energy Junkie

This shows the back of the unit.



This is a graph of the unit heating up when the dial is set to "400".



This shows the unit with the dial set to "367"... actually just a bit past 350.

So the skillet heat controller is working just great. The physical integrity leaves something to be desired, and the elecrtical safety is such that it is inviting an early death.

BEFORE YOU READ FURTHER:

If you are making your own tools, especially electrical tools that are not being used for the purpose for which they were originally intended, you must be aware that you are taking the responsibility for your own safety into your own hands. Be much more cautious than usual, think before you act and DO NOT work alone.

Here is the jig I made to hold the poly pipe in line while it was warmed by the heater and then joined together:

I did improve this jig from previous photos by using a wooden rest for the heater. this rest perfectly centered to heater on the pipe.

The base of the jig is angle iron so that it can be easily clamped to a stable surface. I had envisioned a saw-horse, but ended up using a wooden kitchen stool which worked out just fine. Angle pieces are also angle iron pieces, cut off of the base. The top is smaller angle iron, welded in place, with a space in the middle cut out (after the welds get completely cooled) to make room for the heater and then the fusion bead, when the two ends are pressed together. This jig was originally made for butt-fusion of straight pipe, which worked quite well. We also used it to make 30-degree angle joints as shown here:

After using the jig in this manner, I realized that for small pipe, like 3/4 to 1 inch, hand joining is quite feasible, but having a jig of some kind to steady the pieces is very helpful. I also realized that a welded steel jig is not at all needed, and that a wooden or plastic jig would work also. In fact, even a tin can with the edges bent in like this would work just fine:

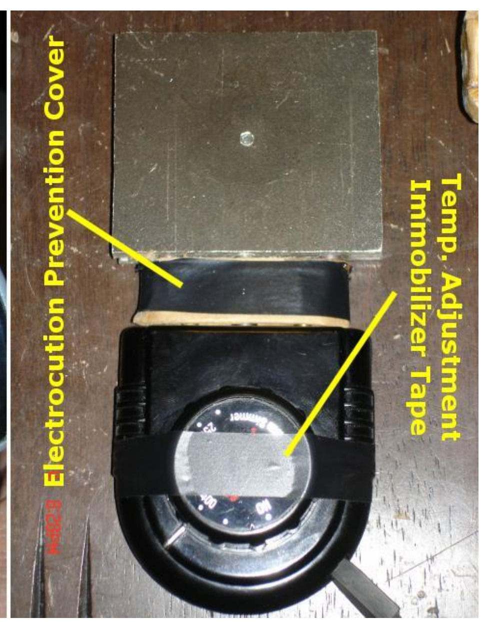
I have come to the conclusion that the professional tools used by the industry actually put the skill of the job into the tool. This reduces training time and increases repeatability. It also costs $2000 for the tool, which is more than I intend to spend on my entire ground source heat pump installation.

We cut the 30 degree angles in the poly pipe with a power chop saw. I used a nice new blade with close-set carbide teeth and it did a fine job.

If there are very minor irregularities in the pipe ends, the heat of the fuser will melt then away. But it would be good to bear in mind that it would be a bad idea to rely on heat to make up for poor workmanship.

The pipe heater worked quite well. I did learn that even though`the tool will reach sufficient heat for the controller to start cycling in about three minutes, the fusion proceedure shouldn't begin until the tool has been powered up for at least ten minutes. This will allow the heat to spread fully to all of the tool, creating a reservoir of heat that will sustain contact with pipe and not drop below a minimum temperature threshold (around 425 degrees).

One handy tool I have used in this project is an Infra-Red thermometer. I used one on the heater that had a range of at least 800 degrees F, figuring that the target temperature range (425 to 550) would be well within it's scale. I bought mine for $40, but you could borrow or rent one to calibrate your tool and carefully immobilize the adjustment knob (I used electricians tape). Using the IR Thermometer, I noticed that the heater would reach a rather high heat, then it would start temperature-cycling with the overall temperature dropping somewhat until it stabilized (aprox. 10 minutes). Arnie observed that "the first waffles just don't taste as good as the last batch". Looks like the same can be said for poly pipe heaters...



Also please note that I made a cover for the exposed high voltage parts...

So here is a photo my efforts:

Planting Plastic...

I decided to do the first hole entirely by hand, to show that it can be done. I used a post-hole auger that uses 3/4 inch water-pipe for a handle. This makes it easy to add extentions so that deep holes can be dug. The cost of this auger new is about $40. You might be able to pick one up for $5 or $10.

Your success will very much depend on the soil characteristics where you dig. You may be able to learn something by talking to the local state or city or county geologist. I talked to one locally and he was only marginally useful. He did refer me to a map that made the call worthwhile. I also went through the yellow pages and called some water well drillers (who often to geo-thermal drilling). They were very helpful, much more so than the geologist. Through all of this I gathered a picture of events that have taken place in this area over the last 15,000 years (yes, fifteen thousand years). I learned that my site was once the river bank of a mighty, raging river. The remanent of that river is now called the Columbia

River, large by modern standards, but tiny by comparison to the old one. So my site has been at various times (and depths) right in te river, and later located a mile or so from the river. The Big River was actually many pre-historic flood events, each leaving it's mark on the layers far beneith my feet. If I were to dig a few city blocks from my site I would only be able to go down maybe three feet with the tools at my disposal. If I were to go in another direction, I might be able to go 40 feet easily. If I were 35 miles from here, in an ideal area, I could easily go down 75 feet.

But I've drill some test holes, and in my site I can get down easily 14 to 17 feet, then I hit 'hard pan', which is a clay and basalt gravel layer that is turning to stone.

So I'm betting that because my climate is pretty mild, and because my house is small, and because I'm doing a much better job of insulating my house than average, I can get sufficcient ground-source heat from 18 holes, each 14 to 17 feet deep.

We began by digging a small hole through the surface roots.

We were hitting roots near the surface so we used a root-hacker tool I had made from a 4 inch cold chisel welded to a piece of 3/4 inch water pipe.

...this tool would have been improved by grinding the chisel at an angle indicated by the yellow line. The root-hacker tool was also useful to loosen the dirt at the bottom of the hole as we went deeper.

The auger went fast:

... and we were ready for a three foot long extention:

...soon we were down to the end of the extention. We also determined that a bit of water helped the mostly sand adhere better, and made it stay on the auger head while we lifted it to the surface"

...and then the 3-foot extention came off and a 6-foot extention went on:

...then the three foot extention went on top of the 6-foot extention:

..soon we were hitting the hard pan

So we warmed up the heater, fused some pipe lengths onto the U-Turn, waited a bit for things to cool off, then down the hole with the poly pipe:

The time code on the last photo is off, but it took less than 5 minutes to fill the hole back up. I have determined not to use grout on my holes because:

1. In the winter time here, the ground is drenched sand, which has thermal conductivity about as good as thermally enhanced grout.
2. Because I'm not going to punch through the hard pan, I will not be causing any cross-aquifer contamination.
3. Easier, cheaper.

So it took about 4 hours to do one hole...

One down, seventeen more to go.

Auger Maintainance

Before I can start using my auger again, I needed to repair some damage I incurred during my last drilling efforts.

When I built the auger, I figured I needed some kind of flex-joint to relieve the bearings in the gear-reduction unit of un-needed strain. I wanted a joint that could flex like a u-joint, but without as much freedom to move. After much scheming, I cooked up a flex-joint made of a pot-metal flange with a keyway and set screw to go on the gearmotor and a 3/4 inch pipe flange to go on the drill pipe. The holes in each flange didn't quite line up, so I drilled my own set of holes, based on the existing holes in the pipe flange. Then I used vibration dampers intended for electric motors to connect the two. It turned out by happy accident that the failure point of the vibration dampers was just about the same point of severe electrical overload of the gearmotor, so the flex joint is also a sort of rubber shear pin. This is the third set of vibration dampers I have installed, but their failure has saved my gearmotor, in spite of all the wild abuse I have subjected it to.

Here is my gearmotor, it's made by Bodine. I wanted a permanet magnet motor because it would be reverseable (much more useful than I had estimated), I wanted around 130 volts DC, because I could run line AC through a bridge rectifier of modest amperage and get the DC I required without a transformer to mess with.

- HP = 1/4
- volts = 130 DC
- Motor type = Permanent Magnet
- Gear Ratio = 20:1

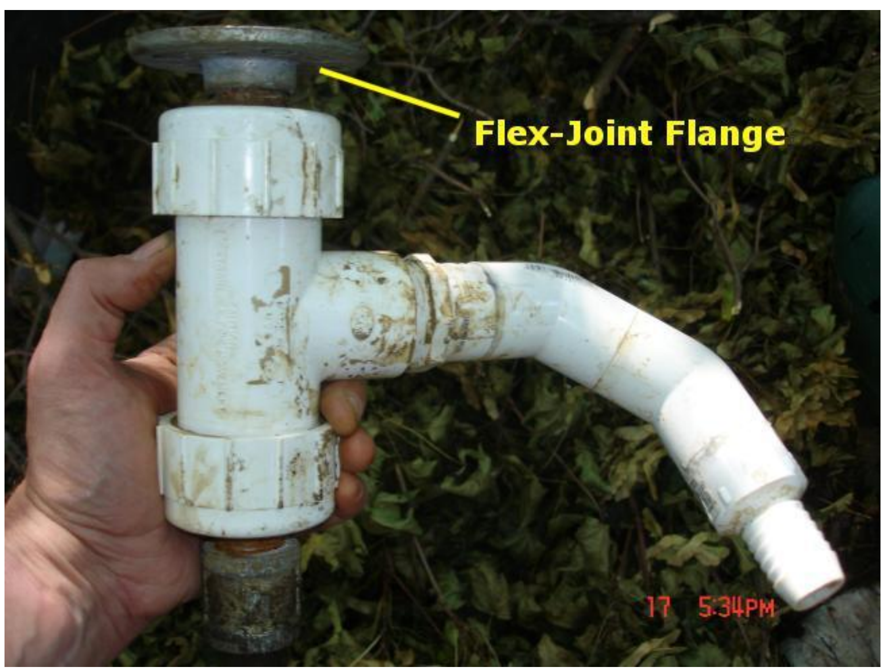
- Torque = 90 in-lb

I welded the motor bracket out of 3/16 steel. It could use some reinforcement at the corner.

Here it the gearmotor side of the flex-joint flange. I really didn't think that the pot metal would hold up, but I tried it anyway. So far so good.

Here are the vibration dampers I use to tie the two flanges together. I use nyloc nuts to prevent them from backing off during use. Works great.

Here is the drill-pipe end of the flange. Also shown is the plastic & sealed ball bearing mud-swivel unit. I'll go into more detail in a future post.



And here is the repaired and complete flex-joint, ready for more drilling.

Having talked to people who dig wells for a living, my 1/4 HP gearmotor auger is so small as to not warrent consideration. The same goes for 3/4 inch drill pipe. The irritating thing is that given favorable soil conditions (no rocks) and limited drilling depth, it does work.

So the methods and tools I have come up with should be considered a 'first pass' effort. I don't know of anyone else who is doing this sort of thing, and I'm really guessing my way as I go along.

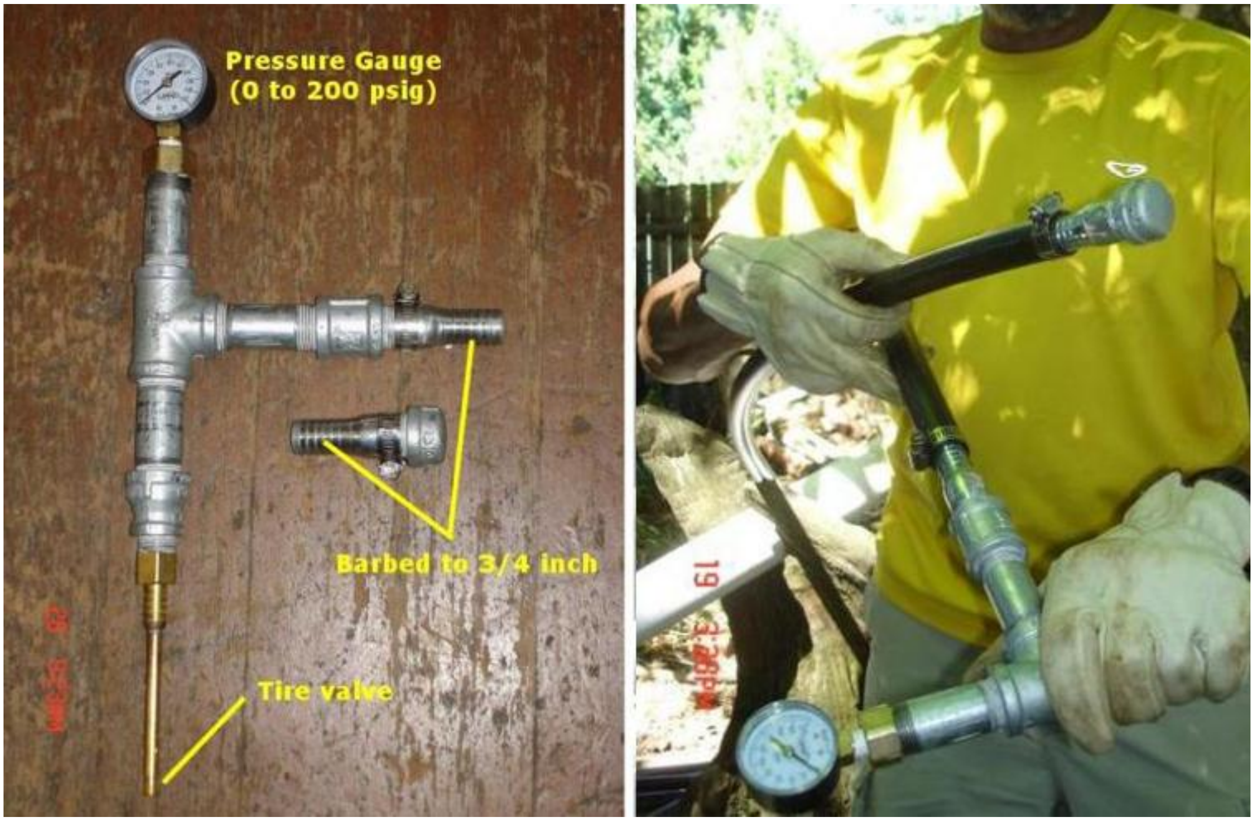
If any readers come up with a solution to these problems that have proven themselves to work better, please chime in. That's the way progress happens, in small steps.

Pressure Testing...

My good friend and distant-relative Ken dropped by the house yesterday and helped me out with welding up the U-Turns to pipe that would go down the holes as they are drilled. I had worked out a procedure to weld by myself but it was much easier and more fun to have someone there to help.

Then, per HJB's suggestion, I pressure tested all of the welds, and I'm glad I did.

Here is the pressure tester I made up for the job:



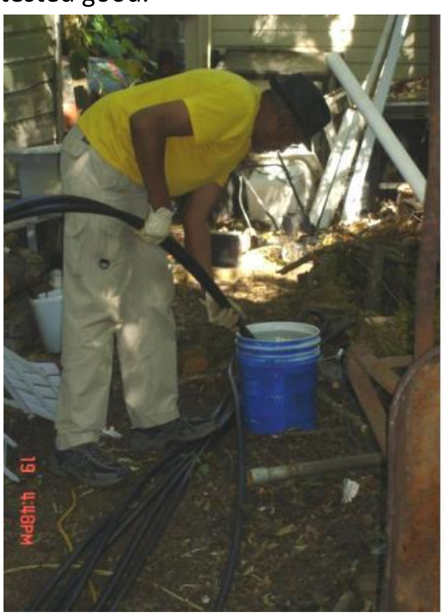
Left side shows the tester. Something to note is that I brazed the tire-fill stem on. It's important to remember to remove the valve core BEFORE you braze, and only reinstall it after everything cools down.

Right side shows distant-relative Ken holding the pressure tester attached to the loop to be tested. Please note that the force of the barb is not enough to withstand pressurized air. We found out the hard way. Ken was worried that he might have a swollen nose from the incident, but everything held up fine once we tightened hose clamps on the pipe over the barbs.

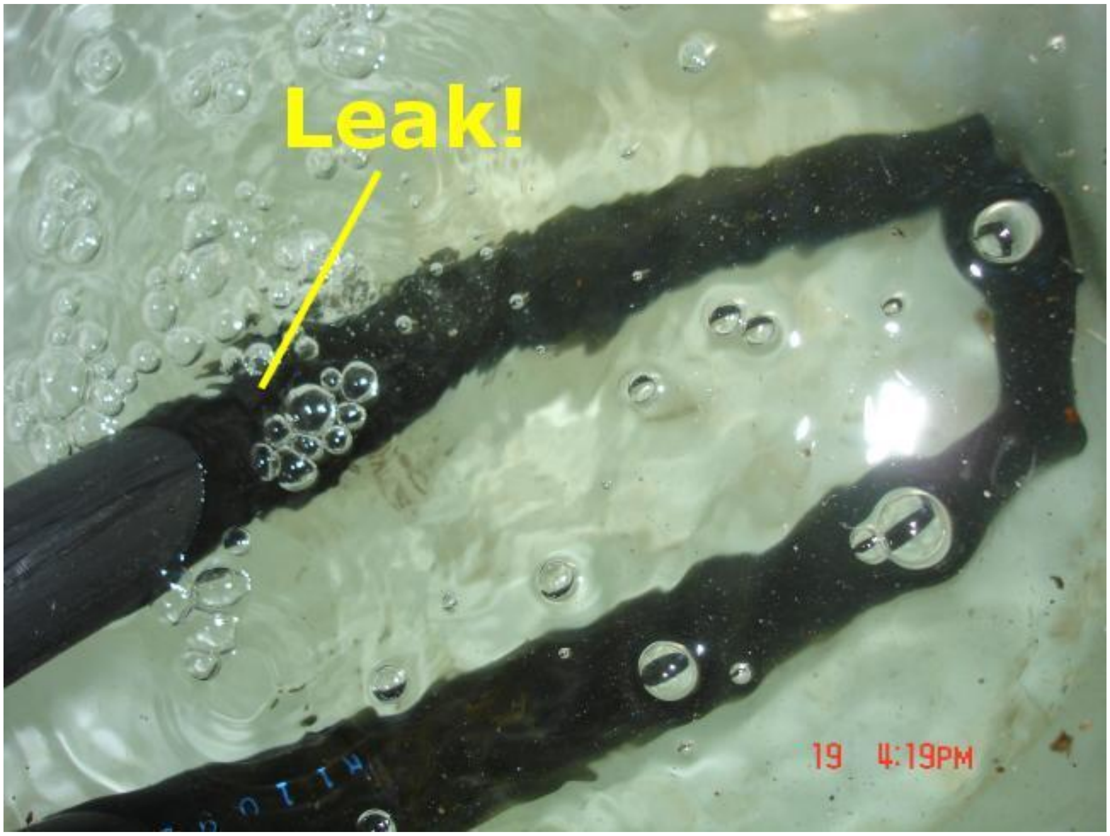
Then we pressurized the system.

I give more credence to the orbit gauge.

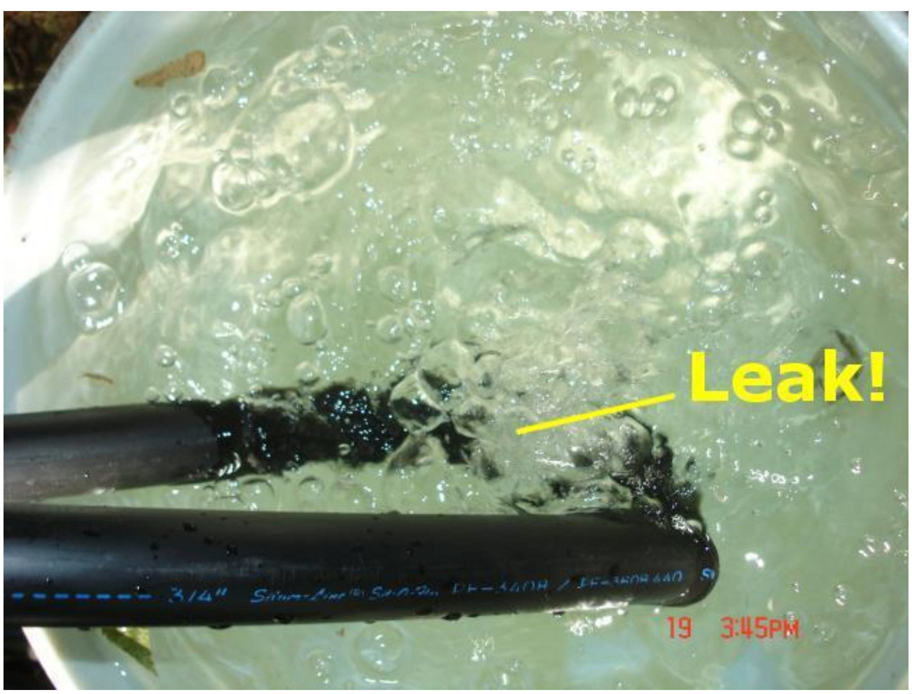
Then Ken put the U-Turn into the water to look for leaks. As can be seen from the right-side pic, this one tested good.



But not all of them tested good as can be seen from this photo:



And here's another leaker:



There was nothing subtle about the leakers, they were very easy to spot with the air-pressure/water test.

So I had two failures out of 18 units tested. Each unit had 5 welds per unit so that was 2 failures per 90 welds, or 1 failure in 45 welds.

Since it only takes **ONE FAILURE** to kill the whole system, testing all welds is mandatory.

So I need to repair and re-test to two bad loops, then start planting plastic in earnest.

This Really Sucks...

I've been slowed down in my 'plastic planting' activities because of the need to prepare for my daughter's wedding and an arm injury brought on by too-exuberant tomato planting.

But I have been thinking about what Daox said about how much work it is to dig holes for the loop-field tubing. There's no getting around it, it is a lot of work.

I've come to recognize that debris removal from the hole is a huge part of the task. So I have developed another technique that is working very well for me...

Here is a photo of a really robust shop-vac I picked up in a thrift store for $15:

This has turned out to be a wonderful tool. If you are considering a similar approach to drilling, I totally recommend the Rigid shop vac. It is very robust and has loads of suck.

My top level (0 ft. to 4 ft.) digging method consists of loosening up the dirt the hole with a pointed iron tool, and sucking out the debris with the shop-vac.

I've calculated that the weight of the dirt coming out of the hole has been running well over half a ton per hole.

I've made up a set of digging tools with various digging tips, one is the 3 inch cold chisel and the other is the sharp end of a demolition bar welded to short lengths of 3/4 inch pipe segments that can also be used for drilling rods with my electric auger tool, previously pictured. I have 4 foot and 6 foot lengths of water pipe that I mix & match to get a proper length digger.

Additionally, I've made up a set of vacuum extention tubes from various pieces of PVC and ABS pipe. I've made two sets, one is 1.5" PVC, The other is 2" ABS.

The velocity in the 1.5" pipe is very high, and the dirt and gravel come sailing through with considerable speed. If there are any stones that are around 1.5", they will get lodged in the pipe but are easily rammed out with a 1.5" ram rod I keep at hand for such a purpose.

I made up a vacuum hose out of 3" flexi drain plastic pipe to use on the 2" ABS tool. The velocity in the 2" pipe is lower, but still adequate for the job. I haven't measured the volume of air, but I'm sure that it is higher, and debris removal is faster. The stones that got caught in the 1.5" pipe pass right through the 2" pipe, so more time is spent removing debris and less time spent removing lodged stones. The down side is that because the velocity is lower, debris doesn't move so well through the 3" flexi pipe and has to be lifted higher than the shop vac periodically to clear the line.

I've also tried 3" plastic pipe, but the velocity in the tube was too low to lift rocks.

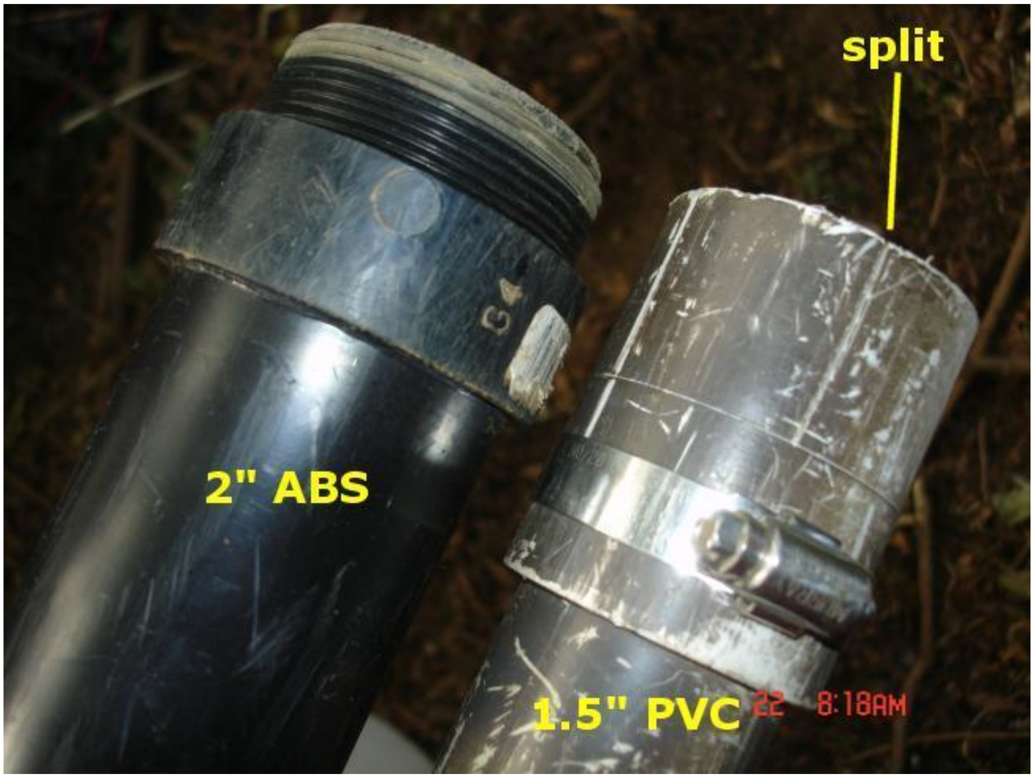
For each of the shop vac extention tools, I followed this scheme:

- The first 10 foot length I left whole, and glued a coupling to it.
- The second pipe I cut in half, so I had a 5 foot piece, with coupling.
- The remaining 5 foot piece I cut to 2/3 length, with coupling.
- This left a piece that was in the neighborhood of 1.5 feet with coupling. I cut the free end of this pipe at a 45 degree angle and attached an illumination module to it (cheap Chinese LED flashlight, fastened on with duct tape) so I could see what was happening down the hole.

I spray-painted black paint over the coupling-and-pipe glued area, to make it easier to identify which pipe the coupling was glued to to make disassembly easier amidst all the roaring, digging and sweat (it's been upwards of 105 degrees the last few days).

On the PVC set, I also made one thin cut with a hack saw through the coupling and used a pipe clamp to hold the joint on strong. There's been a fair amount of swapping of pipe pieces as I dig down and all this has helped out.

On the ABS tool, I found screw-together pipe ends which worked out great.



At the upper levels, the iron digger is required, but deeper, the vacuum and just the 45 degree end of the illuminator-module pipe does it all.

The sound of the vacuum will tell you what is going on... when it has a low, even sound, everything is fine. When the vacuum starts revving up faster, it means that there is a clog. Sometimes there is a wad of damp dirt plugging things up, sometimes a rock has become lodges somewhere in the pipe, and it become necessary to remove the pipe string, disassemble the pipes and ram out the lodged stone.

Be careful to not have your face over the end of the pipe string while the vacuum is on, because an accidental separation of the pipe will make you the target of high velocity sand and gravel. It happened to me... not fun.

Wear safety glasses.

I went on a google expedition to see what was available in the way of industrial vacuums. It would be great to have a larger diameter extention tube and hose, and also a larger sized container. I was able to find 55 gallon shop vacs, but the power & volume wasn't greater than the Rigid. However, the prices sure were! Prices from $750 to $3000, way out of my league. So here's an idea that should be cheap, buildable and enable the possessor of such a device to rule the world:

Two-Headed Suck Monster

This would:

- Hold about 4 Rigid vacs worth of debris
- Enable 3" hose & Extentions
- Have enough volume to clear large diameter lines
- Use a commonly available tank
- Be cheap to reasonable to build

...and of course, allow the posessor of such a 2-Headed Suck Monster to rule the world.

Toward a more perfect union...

My flexi-joint on the electric auger was not holding up so well to all the punishment I have been putting it to.

The shock-mount connectors are working just fine at absorbing jolts and off-axis loading, but I'm watching the fourth set of these suckers fail.

So I tried a Ford/GM steering doughnut replacement part, set up the way it was designed and it worked just fine for about three glorious, high-stress minutes before failing.

So my solution was to use stainless bolts to bolt straight through the doughnut and add some rubber washers atop the flanges capped with big washers, and adjust the nyloc-nuts to 'barely snug'. Under off-axis loading, this allows the bolts and rubber washers to flex just a bit, but under full torque load, the stainless steel bolts carry the full load.

After about five hours of high stress digging, the new system is working perfectly.

Problem solved.

The Swivel Story...

the water swivel is used to transfer water (or drilling mud) down a rotating drilling pipe. The purpose of this is to lubricate and cool the drill bit, and to flush cuttings up and out of the hole.

They can be purchased on ebay currently at this link:

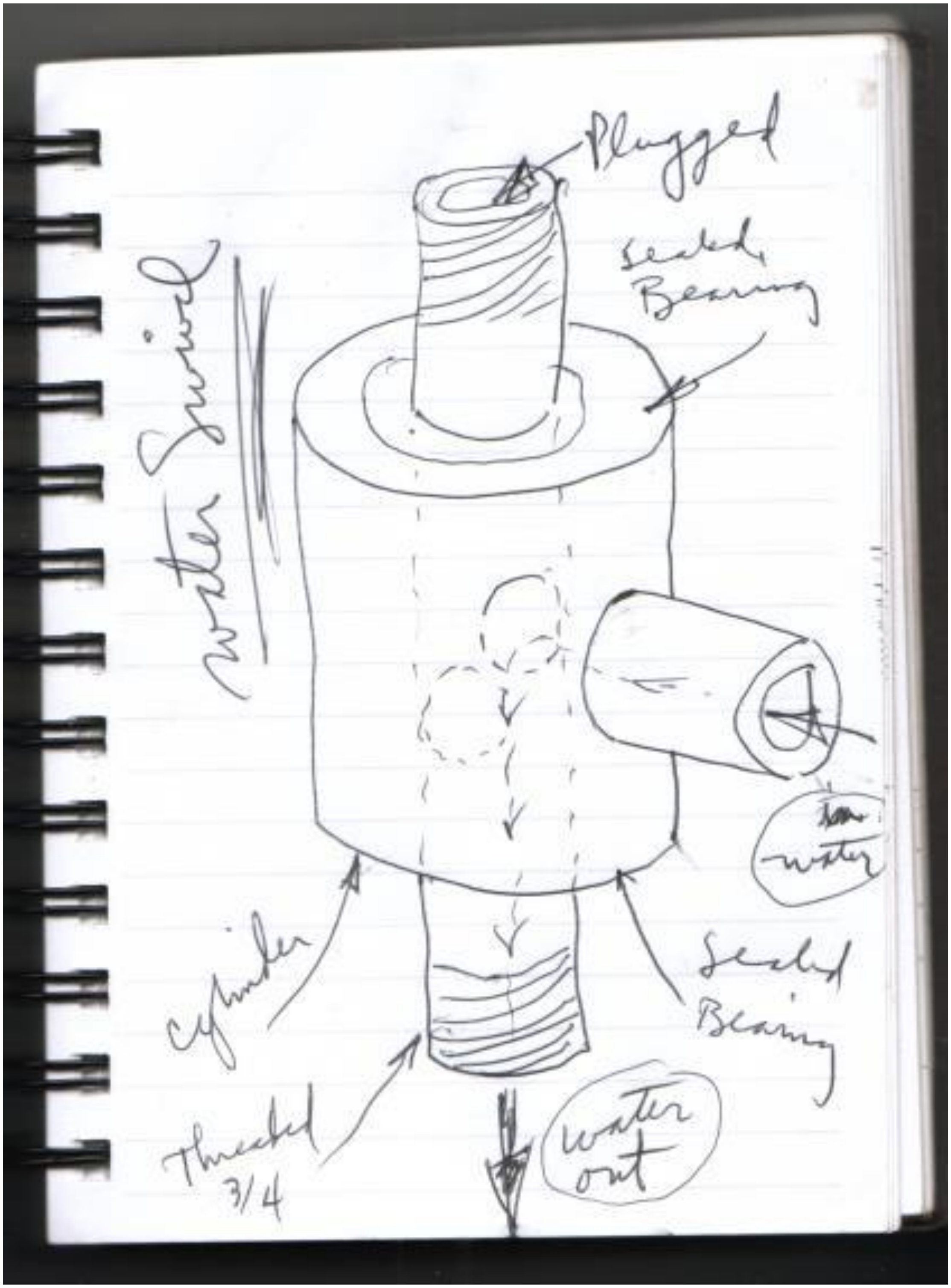
water well swivel, great deals on Business Industrial on eBay!

I've been trying to reduce cost on this project at every step, so I made my own.

I don't currently have a lathe, so I tried to find off the shelf parts to do the trick. I made two different kinds, here's the best...

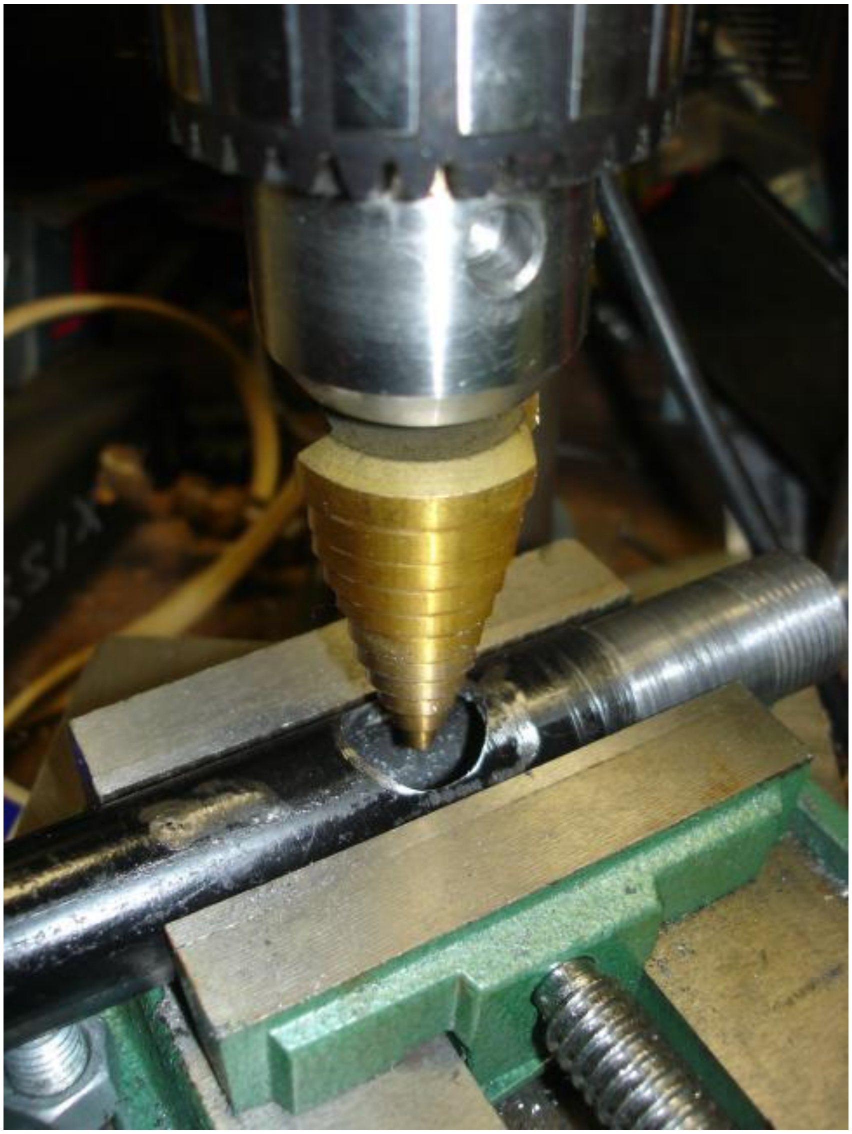
Against all advice I decided to use 3/4 inch drill pipe. I now realize that for really serious drilling 3/4 is too narrow and constrictive to transfer the amount of water required to drill deep. However, for depths such as I'm undertaking, it works just fine.

Here's a drawing:



I forgot to label the holes that are drilled in staggered positions (for strength) on opposite sides of the pipe.

Here's a photo of the drilling in process:



...so you'll want to stagger the holes and both holes should have a combined area a bit bigger than the ID of your drill pipe.

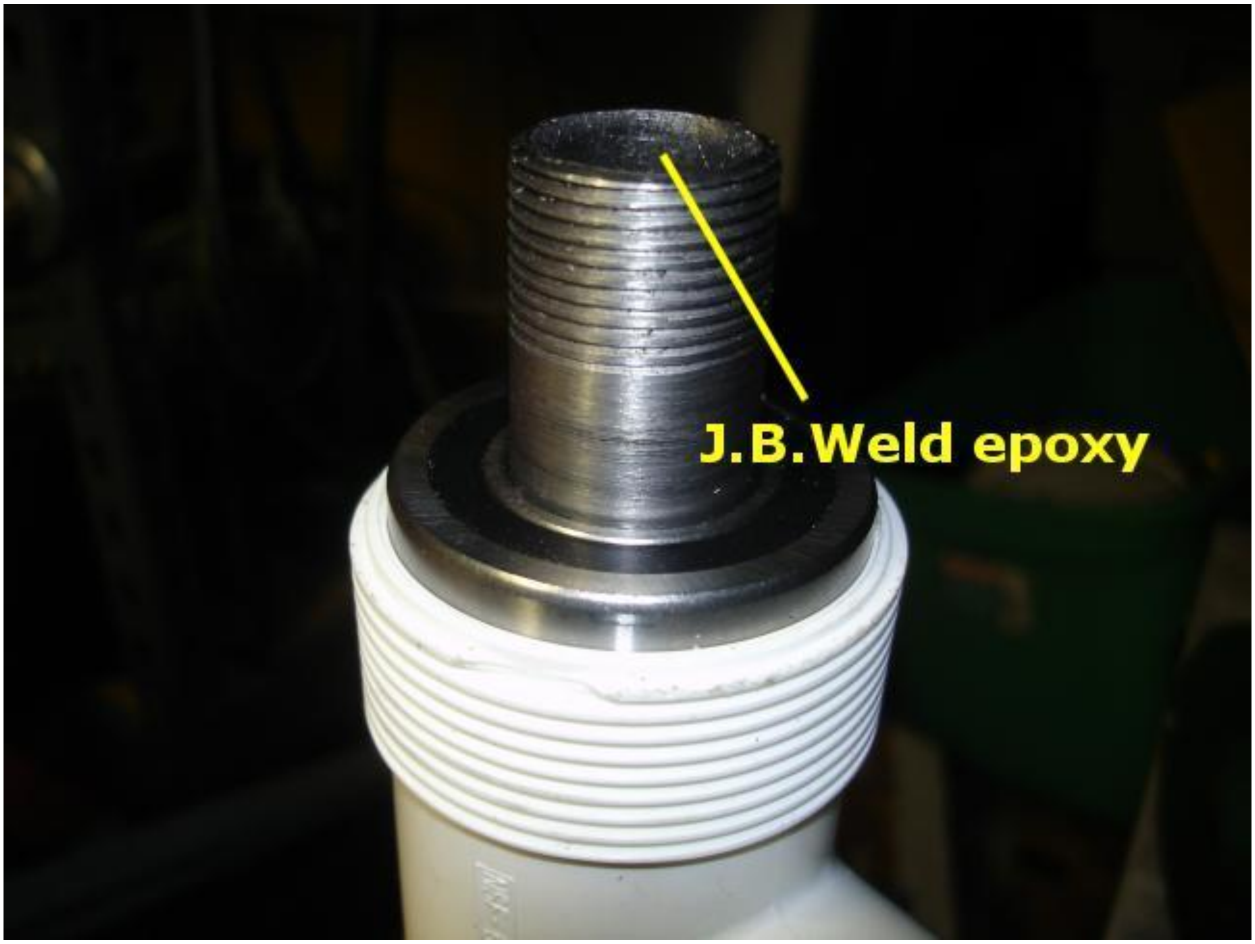
Now the trick is to find a shell and a bearing that require minimum machining to fit up properly.

Here's what I came up with:

The white shell and screw-on end caps are from Ace Hardware and are called a 'PVC 1 1/4 inch compression T'. Throw the rubber compression thingies away, you won't need them.

Here was the real breakthrough: The bearings are not measured in millimeters as bearings usually are, but are inch bearings. Get one that has an ID of 1 inch. The bearing OD must be specified to be the same as or just slightly smaller than the ID of the compression T. I found one (sorry, I forget the exact OD of the bearing) that was a perfect snug fit inside the PVC plastic compression fitting.

The 3/4 pipe OD will have to be skimmed down a few thousandths to be a proper press-on fit to the inside of the sealed bearing. This will take off the tops of the threads, but not enough to affect strength.



I stuck some bread dough about an inch down into the top end pipe and filled it up with J.B. Weld to form a plug so the water wouldn't get out.

If you want to use the rotary mud drilling technique, your rotating motor doesn't do much of the work, the water and mud become the real tool.

If you need to drill through sand/clay, mud drilling progress is really fast. However, the mud does obscure the soil you're going through. I really learned a lot about the soil characteristics, sand characteristics & soil moisture zones etc, by digging dry.

Hope this helps...

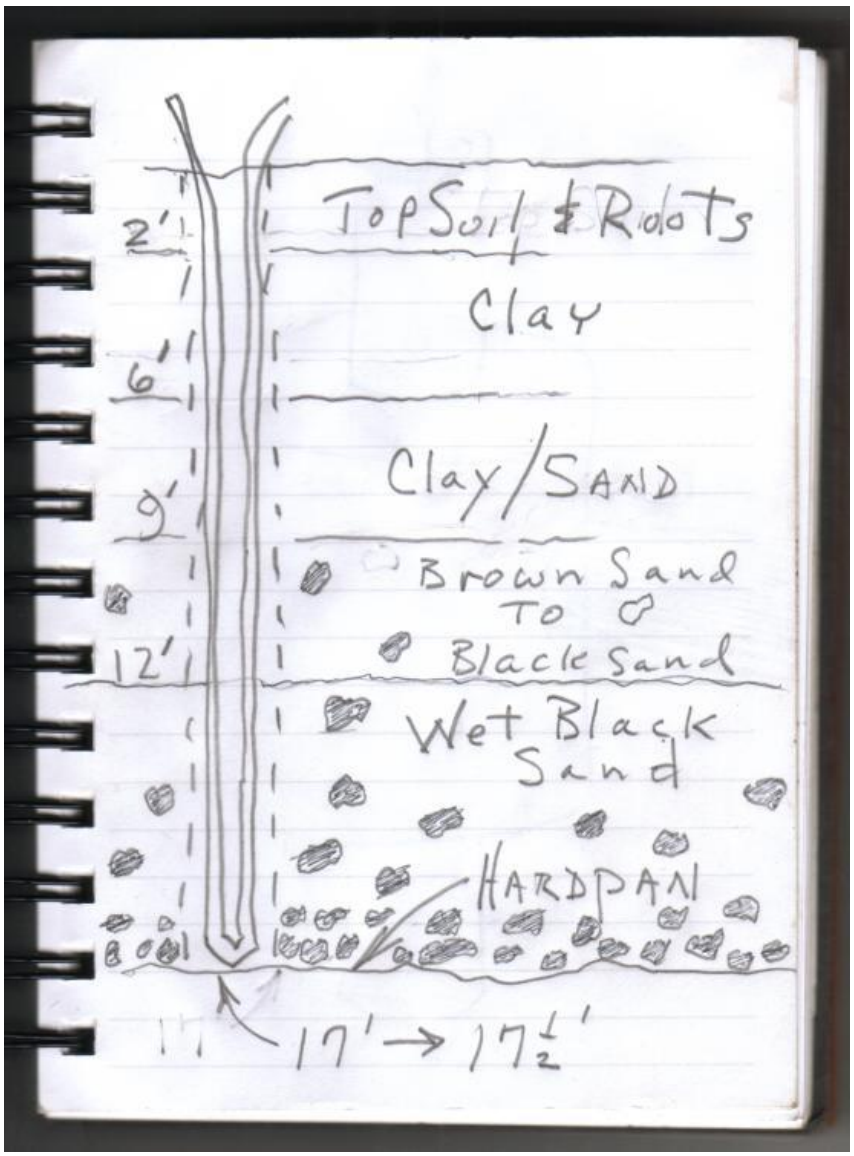
Drilling Report Aug 31, 2011

Yesterday I finished up hole number 11 of 16.

I thought I'd summarize what I have learned so far about this process. I'd be very surprised if anyone experienced soil conditions exactly like mine. I'd be much more surprised if no one had any of the experiences I have had.

So I offer the following information in the hopes that at least some of my experience can be useful to those who might want to try to make their own loop field.

Here is a diagram of the soil conditions I have encountered in every hole I have dug:



TOP 2 FEET - sand/clay/organic bits

The top two feet I initially started with a shovel and a pointed steel rod, to loosen things up. At first, just tossed the dirt on the ground near the hole, not realizing just how much was going to come out of the hole (and also not realizing that it would all have to go back into the hole). On subsequent holes, I used a 55 gallon barrel to hold the dirt while I was digging. This makes is very much easier to get the dirt back in the hole.

In my experience, roots are a problem in the top 2 feet but really not much of a problem any deeper. I started using the Shop Vac on the second hole to remove debris, and it really helped in dealing with roots, as once the dirt was vacuumed away from the root, it became very apparent exactly where to cut to remove the root.

I tried hacking out the roots with a sharpened cold chisel welded to a section of water pipe, but it didn't work nearly as well as going in with a reciprocating saw.

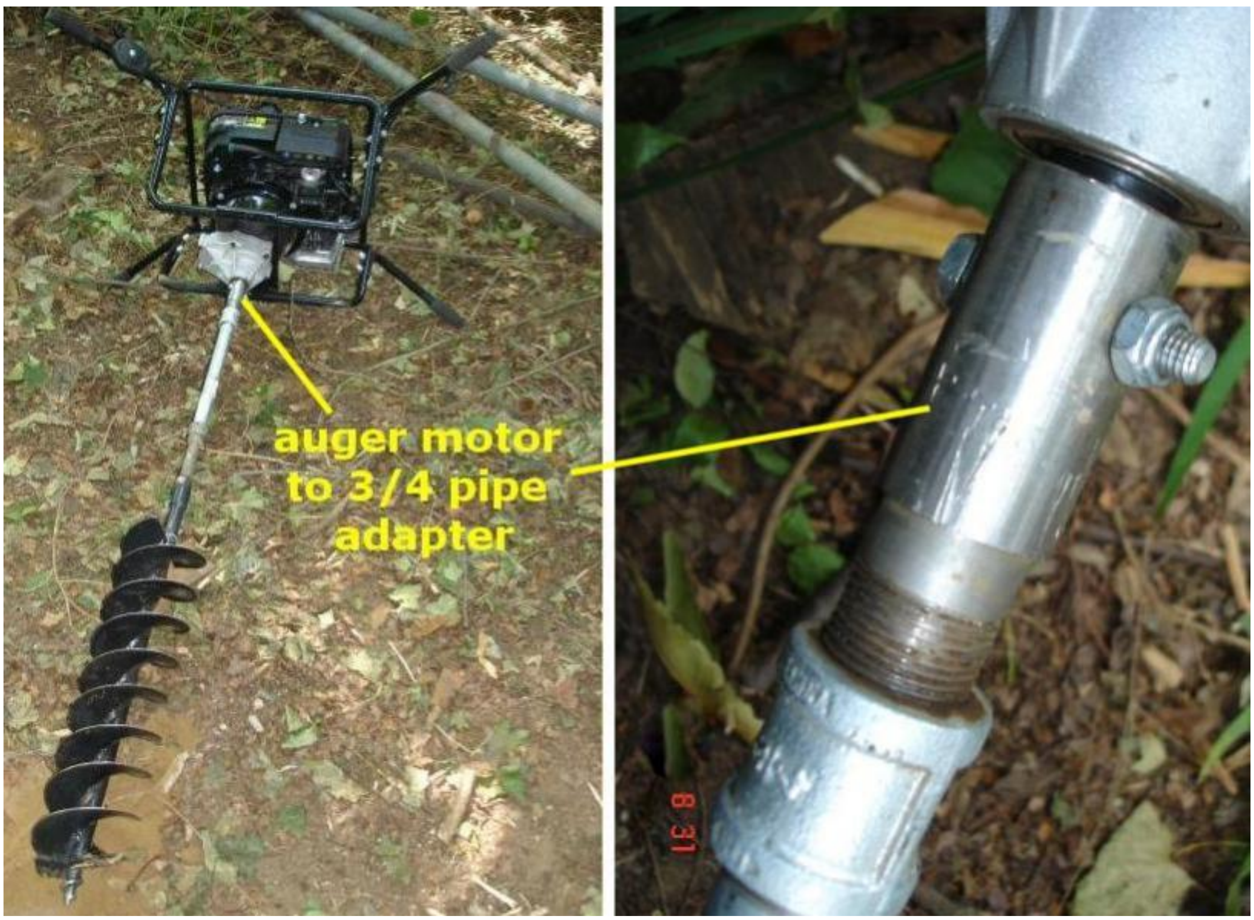
The top two feet were very easy to get through, the soil was sand and clay, but there was so much organic matter mixed in that the soil was 'light' and easily penetrated.

2 FEET TO 6 FEET - clay to clay/sand

This was the toughest layer to get through. The clay was pretty dry and hard. Initially I tried just a hand auger. It was slow, exhausting work. Using a pointed iron digging bar to loosen things up a bit, ahead of the hand auger helped, but it was tough work.

I tried various diggers and bits on my electric auger, with better results, but only 1/4 horse power, it could only push a three inch bit (see photo above) about a half a foot into the clay, after which I'd have to bash away with the pointed steel bar and vacuum out the debris, and back to the electric auger, etc, etc, etc. On every hole, there was a particular layer of clay at about 4 feet deep which was very tough and it took at least an hour of drilling and bashing and vacuuming to advance six inches.

So I got my hands on a 5.5 HP post hole auger and drilled out the remaining holes to the depth of the auger bit, about 36 inches. I also had Howard-the-machinist make me an adapter so I could put on an extension and drill deeper.

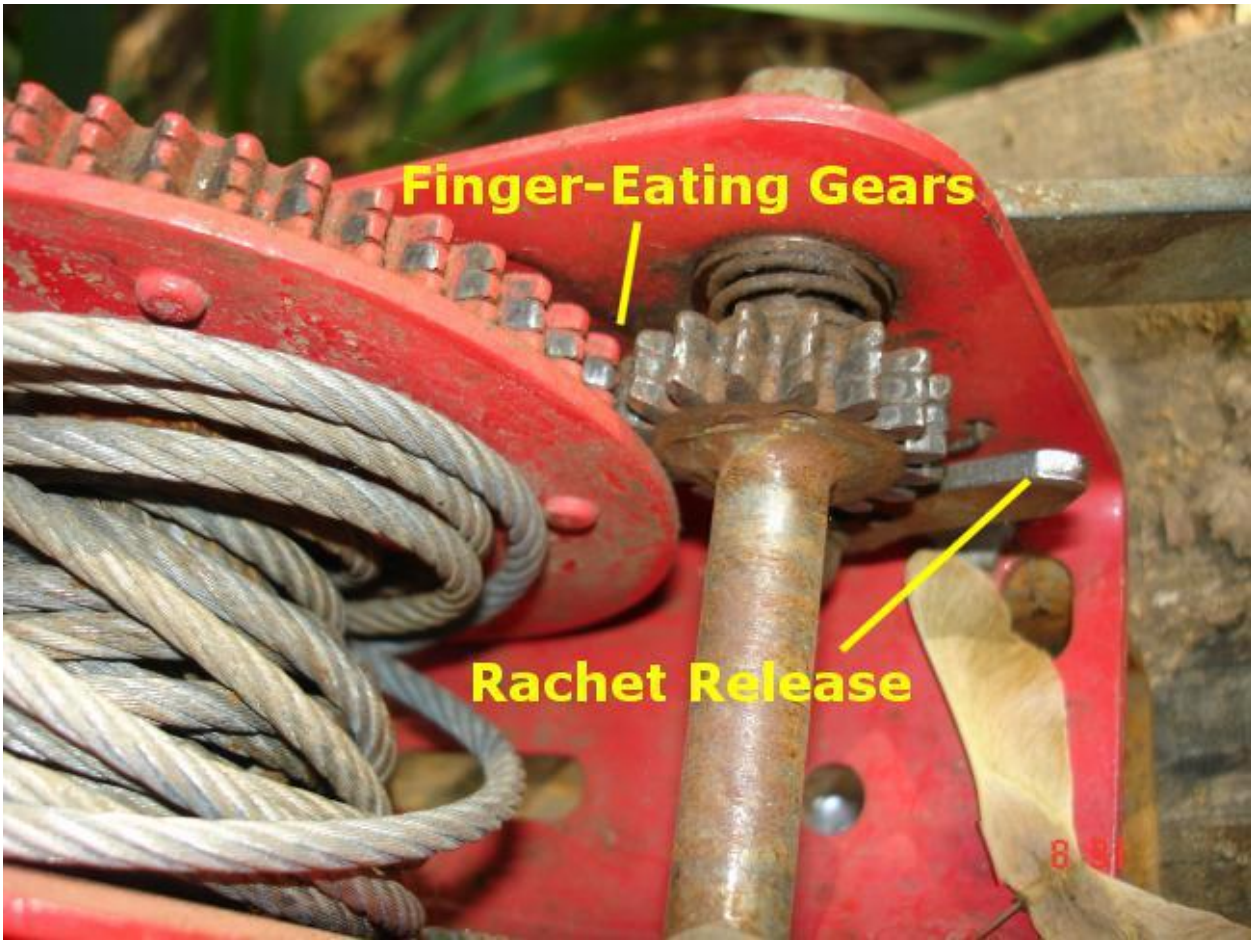


To my disappointment, the post hole digger didn't exhibit the advantage of power I had expected. I tried putting water in the hole a couple of days before drilling, but when I hit the tough layer of clay, it wasn't just tough but it was tough and slippery.

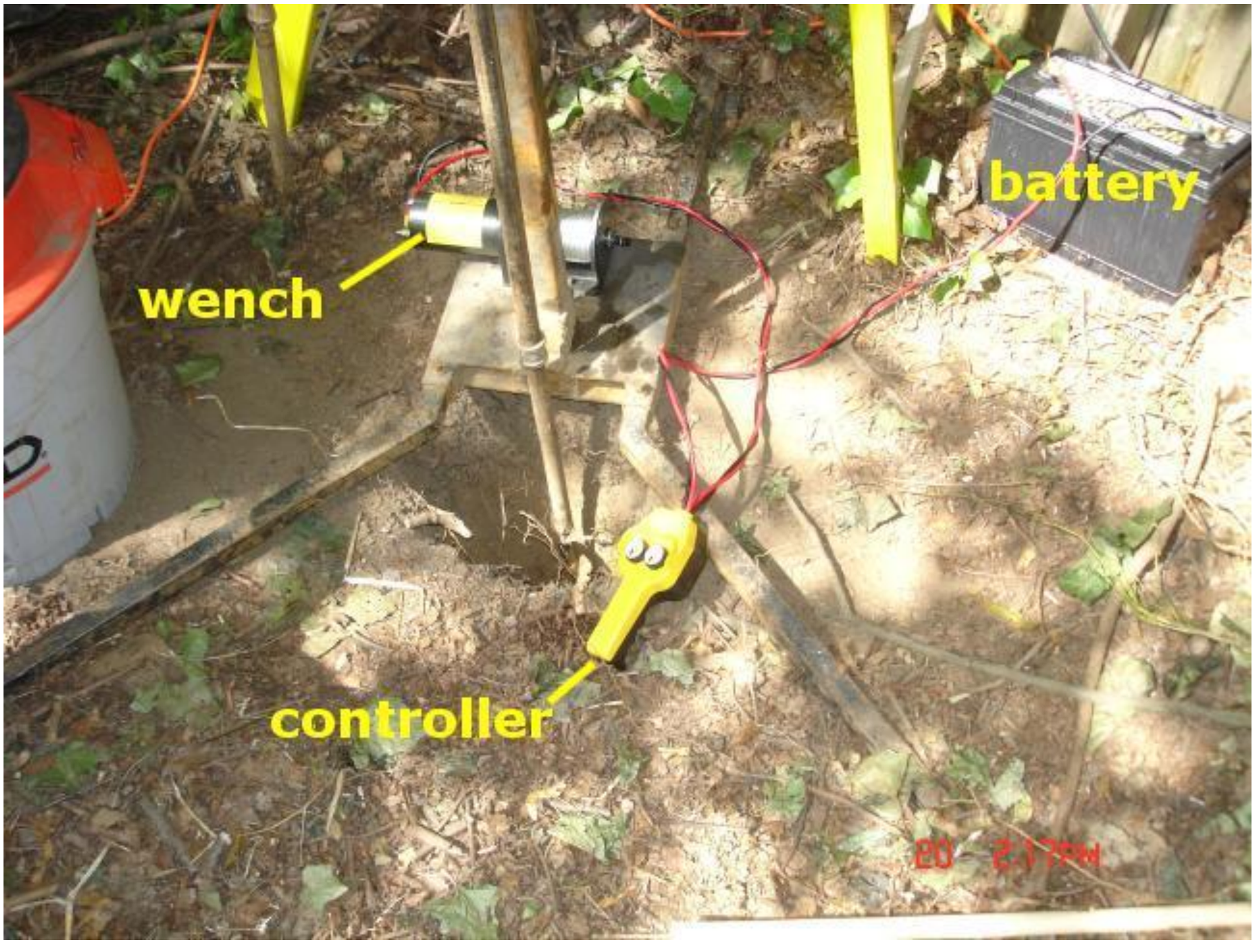
I tried a smaller diameter post hole auger bit and that did help in some cases, but not all.

It seemed that the ultimate approach was drilling, bashing with the pointed iron bar and vacuuming, and repeat, and repeat.

I did make an improvement to the electric auger which has helped, and that is I added an electric wench to the drill stand. A 120 volt wench would have cost me about $100 + bucks, but I got a 12 volt model on sale for $50. I had a spare 12 volt deep discharge battery laying around and a battery charger, so it was pretty easy. The real reason I added the auger is that the manual wench had open gears and I came very close to getting my fingers in the gears more than once. I have been playing guitar most of my life, and I have grown very fond of my fingers.



Also, the last time the finger tips nearly went into the gears, I did a hasty calculation of what it would cost to take a trip to the emergency room, and compared that to the $50 for the wench, an I found myself driving to the store to get the wench.



After I have managed to get through the layer of clay at 4 feet, the soil composition becomes a mixture of brown sand and clay, with the percentage of sand increasing as I go deeper. Here the electric auger works just fine, and has saved me loads of hard manual work.

I've tried lots of different bit designs on the electric auger, but the one that works the best is the bit from a manual post hole auger bit.

I make a temporary mark on the electric auger's vertical tube to keep track of drilling progress and let the auger do the work. I have found that after it has dug about 4 inches, the auger bucket is full, so I use the shop vac down the hole to vacuum out the debris and then drill down another 4 inches, etc.

Sometimes when working in this mode, the auger is turning but stops progressing, so I have found that rocking the auger stand back and forth seems to concentrate the force on an edge of the auger blade, and the auger digs on down again.

I can usually get from 5 feet to 8 feet pretty fast, maybe an hour's time.

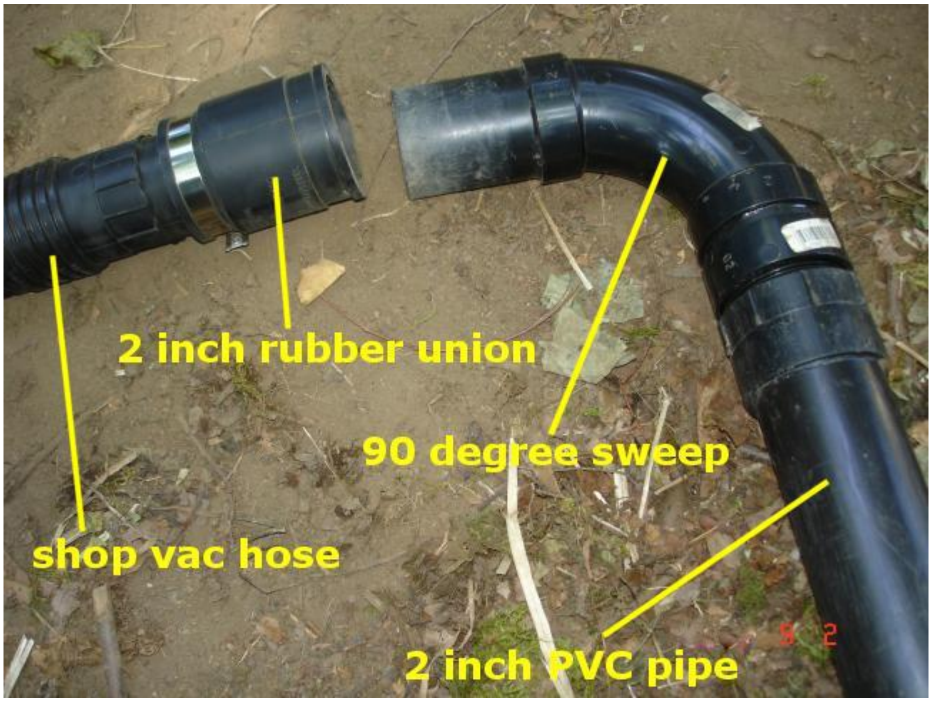
6 FEET TO 9 FEET

At about eight feet, I start seeing black sand grains mixed in with the brown sand, so I know that the wet black sand layer is not far away.

After every five or ten buckets, I try removing the auger from the hole and try using the shop vac alone. If it works poorly, I continue with the auger, if it works well, I switch methods and use the shop vac alone. I put the 45 degree tip on and rotate the PVC pipe back and forth. This way the pipe acts both as a drill and as a debris remover, in one operation. The shop vac method is easy, fast and much safer than the electric auger.

I have used two shop vacs, one is from Lowe's and is rated at 4 HP. The other is a Rigid rated at 5.5 HP. Using a shop vac for drilling a borehole into the earth is at the very least 'cruel and unusual punishment'. As I said before, I estimated that the dirt removed from each 17 foot deep hole weighs about a half ton of dirt and rocks. The Rigid is up to the task, the Lowe's shop vac is not. This is not necessarily an endorsement for Rigid shop vacs, rather advice on choosing the right tool for the job.

I have found that the 2 inch PVC pipe works best. It sucks up great volumes of dirt and a surprising amount of stones get drawn up as well. I finally wised up and added a larger-radius PVC 90 degree turn (NOTE: large radius turns have less friction loss than sharp 90 degree elbows) to the top of the PVC pipe, and use a 2 inch rubber plumbing adapter to connect the shop vac hose to the PVC.



I use the hose clamp on the shop vac side, and use the rubber side loose on the PVC side. When the shop vac is running, the suction keeps it all together very well. The surprise benefit is that the 90 degree bend gives me a handle for rotating the pipe. And best of all, no more vacuum-hose kinks.

Blockage of the suction line is a very common occurrence. It usually occurs from stones, but can be a glop of wet sand, a leaf fallen into the hole and wet sand can do it to.

At first I thought blockage was a setback, but now I see that every blockage removed is just that much more material that is not in the hole any more.

The rubber slip-fit mentioned above, allows me to quickly disconnect the shop vac from the PVC to determine the location of blockage. I can tell when things get blocked because the shop vac will increase its RPMs dramatically. If the RPMs reduce to normal when the slip-fit is separated, it means that the vertical pipe (see photo on left above) or the PVC 90 degree bend is plugged (see photo on right above), usually but not always at the tip.

If the shop vac is still reving very high, it means that the hose is blocked or a stone has gotten lodged near the opening of the vac unit.

I have become so attuned to this process, that I can tell if the blockage is a round stone completely blocking things, or a flat stone causing a partial blockage.

9 TO 12 FEET

In my situation, more black sand means less clay and very fast removal, but it also means more and larger stones, which present unique problems.

William_Hackerson suggested that we needed some kind of down-the-hole claw to remove rocks. Here's what I came up with:

Here's another shot with a carpenter's tape for scale, along with a rock I hauled out of the hole using the claw:

If part of the claw looks like a wrecking bar, there's a very good reason.

As stated previously, clay is really tough to get through. But I have had some success as of late.

I got to thinking about my earlier efforts in using a water drill or water and/or mud drill and remembered how easily it cut through the clay layer. So I designed and built another very agressive water bit to be used just to get through the clay, thinking that then I'd go back to the shop vac for sand & gravel removal.

So here's the bit I welded up. I took the photo with one hand while I held the bit with the other hand, because the bit was still too hot to touch.

I had considered tempering the cutting edges, but figured that the bit will see only limited use so I decided to use as is.

Here's a pic of the business end of the bit so you can see how I left the end open for water flow.

And here's a shot of the business end with water running through it.

As you can imagine from a dirt's eye view, with this thing coming at you, rotating away, and water blasting out all the clay and sand debris, the clay just doesn't stand a ghost of a chance.

What had formerly taken me an hour or two of arduous hacking and vacuuming, took maybe 5 minutes of watching the auger do all the work.

If I were in a situation of digging a loop field in ground that was all sand and clay, I wouldn't hesitate to use a rotating water bit. I would also not use water as I did today, but I woud use drilling mud, because it prevents fluid loss through the sand, and it inhibits cave-in of sand.

Here's a link to the stuff I used before:

QuiK-Gel, 50lb. Bag, 200 mesh Wyoming sodium bentonite, drilling mud : Mud - Directional Drilling : Atlantic Supply

I was having the problems of fluid loss, and cave in and the mud cured both of those problems. But the problem of rocks it just couldn't help. It also obscured the soil characteristics so that I really couldn't tell what was going on.

You might overlook the need for a husky flow of water or mud down the drill pipe. With rotary mud drilling, the fluid becomes at least as much of the tool as the metal and motor. So you'll want to minimize friction losses and get a pump that will really gush. For my pruposes, I used a 1.5 HP electric pump that worked pretty well. I measured it's flow rate against that of city water andd found it was 2x the volume. Worked great. Mud and sand and bits of gravel are really hard on pumps, so get one called a "trash pump":

trash pump - Google Search

...or get a really, really good guarantee.

So if you're going to go the route of mud/rotary drilling, you'll want to set up some kind of recirculating system so that debris settles out of the fluid that is forced to the top and will send the liquid mud forcibly back down the drill pipe.

Here are some links regarding rotary mud drilling:

Mud Rotary Drilling

Mud Rotary

There's plenty more on the web, but the gigantic size of what the professionals use is not always easy to reduce to DIY scale.

There are some church groups who have done some reasonable work on small scale drilling. Some videos also on youtube:

YouTube - well drilling

Some are crafty, some are crap, mine them for ideas.

So for me, getting through the clay, I figured I'd be going through about 2 cubic feet of clay per hole, and decided to just use water and just let the clay wash up onto the ground.

After I made it through the clay, I used the shop vac again in "wet mode": and sucked out the water and as much of the mud as I could. It took 2 or 3 vac loads per hole, but it sure beat bashing away relentlessly with a sharp iron rod.

It was a bit sticky for the first few feet going through clay/sand, but again better than clay bashing.

I'm working on the last four holes simultaneously, gas augered them all, used the water bit on them all and am now electric augering down to black sand where I can start in with the shop vac.

One thing that I learned previously that I need to include is that there is wet drilling and there is dry drilling and as I have found, each has it's benefits and its drawbacks.

The spiral auger bits like you might find on post hole diggers are fine for dry drilling, but all of those radiating "fins" can really work against you if you want to drill wet. If you have mud and water in the hole and a spiral bit, the bit can become stuck in the ground, due to all those horizontal surfaces.

I found out the hard way at the beginning of last winter, when I got a nice new $100 spiral bit stuck 8 feet down in a cold, muddy hole. I tried to pry it out of the ground with a hydrolic engine hoist and very heavy chain fastened real close to the hydrolic cylinder.

There was straining and groaning of the hoist and then a peace-shattering bang as some substantial steel failed in shear.

That new auger bit is still 8 feet down in the ground, and on cold winter nights, I can still hear it calling my name...

Equipment Failure

Last Thursday, I had made great progress having finished the fifteenth hole.

I also suffered a setback when the pully which is at the top of my drill set-up failed.

I was trying to extract an auger from the hole #16 and the forces generated by the 2000 pound winch easily deformed it.

I wasn't terribly surprised as the pully was actually made for reeling in clothes line. I had estimated correctly that it was a good match for the manual winch, but the power winch was just too much for the light assembly.

So I bought a winch-grade pully and rebuilt the pully-carrier, this time with much stouter steel.

Problem resolved.

So now, with the show...

Hole #16 Prior to Filling...

*** * LOOP SPACERS * ***

There's one important detail I forgot to say earlier...

I read that the performance of the boreholes is improved by keeping the 'down-the-hole' and 'returning' pipes separated as much as possible. There is a commercial product that is available that does an excellent job I am sure. But I made my own out of thin-wall irrigation tubing I had laying around and some bicycle tubes cut into strips. The local bike store most likely has a barrel filled with dead inner tubes, just waiting for you to come get some.

I put the spacers on the loop pipe at intervals of 3 to 5 feet.

In the beginning of this project, I bought 100 feet of thinwall 1/2 inch irrigation tube for $10. I soon realized that it would be crushed by the weight of the earth, so I didn't use it, and I had 'munged it up' enough that I couldn't take it back either. But it did turn out to be very useful for tubing spacers.

In the picture at the top are some spacers I cut from the plastic tubing. Since the holes varied in size, I cut a large number all at once, but varying in length from 4 to 7 inches, to fit various situations.

The photo on the bottom shows some strips of bike tires I cut into strips to use for tying the spacer-tubes onto the poly pipe loops.

I looped the tire strip around the poly pipe as shown in the photo below:

The photo above show how I passed the tire strip ends through the small tube.

And tied the free ends around the other leg of the poly pipe loop as shown in the photo below.

The photo above shows the spacerin place, doing its job of keeping the poly loop pipes spread apart. One nice thing about the thinwalled irrigation pipe is that if I mis-calculated the width of the borehole and put in a spacer that was too big, the thin-walled tubing would collapse a bit.

Toward the end of this phase of the project, I developed an alternate method which may be more appealing, and that was to make a wire hook out of coat hanger wire to be used with rubber bands cut from a fat tire bike tube. I tried a mountain bike sized tube for making rubber bands, even cutting them at a diagonal, and they were just a little bit short. I didn't try it, but I think that a 'fat-tire' innertube would be just right.

Upper picture shows the hook, with an orange ribbon attached to aid visibility, the tube spacer, and a diagonal-cut rubber band.

As shown in the bottom pic,the rubber band would be slipped over one leg of the loop, then the wire hook would be pushed through the spacer tube, hooking the rubber band. Then the hooked rubber band end would be pulled through the tube and slipped over the remaining leg of the loop. Several of these would be put over the loop, then slid into place at desired intervals.

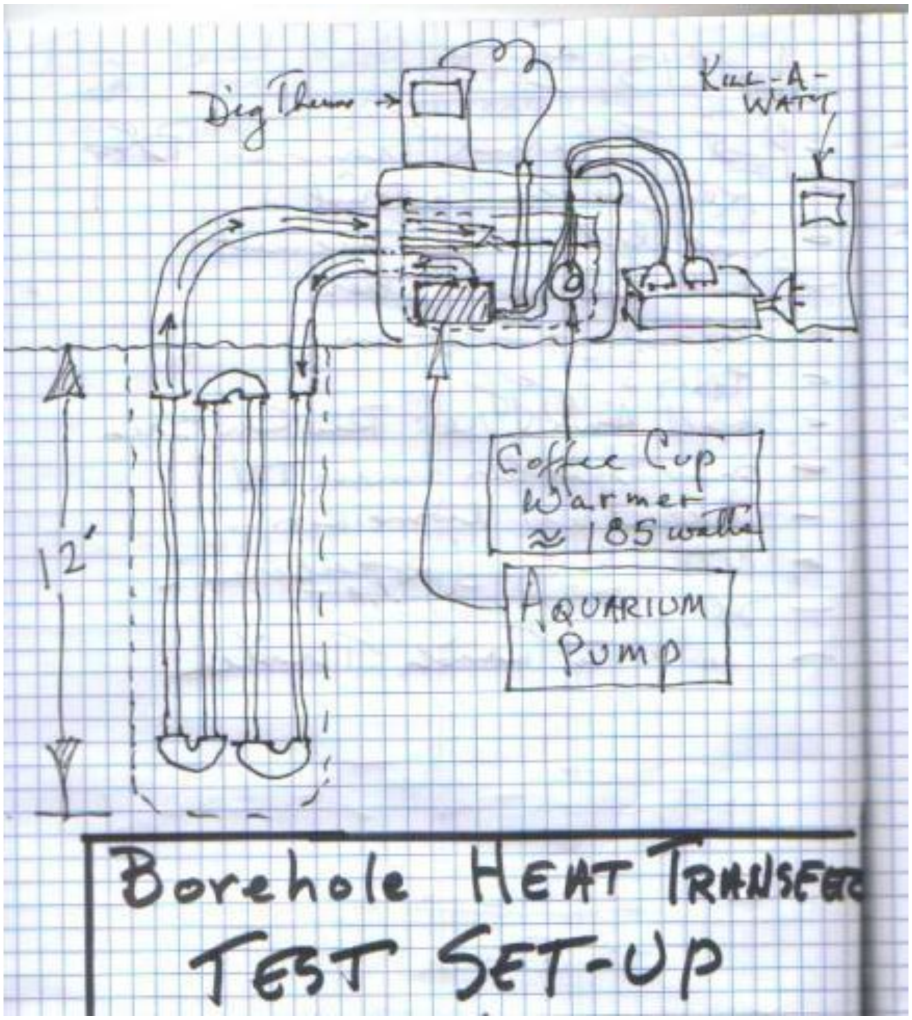
I tried this method toward the end of the hole drilling phase, and it was just about as fast as the tying method, using cut strips, and I could see that with a bit of practice, the new method would go faster than tying.

Next is Trenching...

I'm trying to co-ordinate the trencher with a friend who is replacing water main pipe at his place... save us both some money.

I'm also re-testing for leaks on all the U-tubes.

And I will repeat the thermal transfer test I did previously, this time with HDPE pipe I'm actually using and hole depths I'm actually using.



Trenches are all dug...

10 Day Forecast - F° | View the Detailed Extended Forecast »

Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
sep 19	sep 20	sep 21	sep 22	sep 23	sep 24	sep 25	sep 26	sep 27	sep 28
AM Showers	Partly Cloudy	Partly Cloudy	Sunny	Sunny	Sunny	Mostly Sunny	Sunny	Sunny	Sunny
69° 52°	74° 51°	86° 57°	91° 60°	88° 60°	74° 56°	74° 57°	77° 58°	77° 57°	76° 58°

With a favorable weather forecast, I decided to work like a demon while time and weather are on my side.

I went in with my friend Bruce-the-Pirate to rent a trenching machine. We visited the local power tool rental establishment to see what they had.

We selected a Ditch Witch which was probably second choice, but it did have the advantage of being 'maneuverable'. It turns out that this type of machine has no real steering, it just goes backwards in a generally straight line and digs as it goes. Changing direction is not easy and consists of grabbing this horribly heavy machine and using all of your strength and moving it a few degrees, then repeat until properly positioned.

But once positioned, the controls are all hydraulic and the engine is fairly powerful and it sure beats digging by hand.

So the trenches went in and great care was used to not damage any of the polyethylene loop pipes.

The pic at the top shows how the trencher was run up close, but not touching the pipe...

...the pic on the bottom shows digging the trench next to the loop pipe.

By the way, I asked the man who ran the tool rental store what they had in the way of hole diggers. He asked how deep, I said maybe 20 feet, he asked how many and I said maybe twenty or so, he threw up his hands and said no, there was nothing like that, and went on describing how it could not be done.

I told him that I had already dug sixteen holes that were each seventeen feet deep, with a shop vac!

I didn't have my camera, but this was the look on his face:

Some Useful Links :

And just in case anyone might miss it, your link also contained this link to a PDF with detailed but dated instructions to build your own vacuum pump:

http://www.belljar.net/fbleeconversion.pdf

And here is a link to HVAC vacuum pumps on ebay:

vacuum pump, great deals on on eBay!

Additionally, here is a link to vacuum pumps at Harbor Freight:

Harbor Freight Tools

Harbor Freight used to carry a 1.5 cfm pump which was cheaper than any in the above link, and would work fine, though more slowly.

And here's a discussion from an HVAC blog about how you can't/can/can't/can
build a vacuum pump from a refrig compressor:

Compressor ID for DIY vacuum pump - Refrigeration-Engineer.com forums

Welding vs. Barbs...

Earlier I showed how to make heat fusion (AKA: plastic welding) tools.

So far while installing the loop field, I've had some situations where I thought I'd have to resort to barb connections rather than welded pipe. I got some brass barbs and installed them up and tested them.

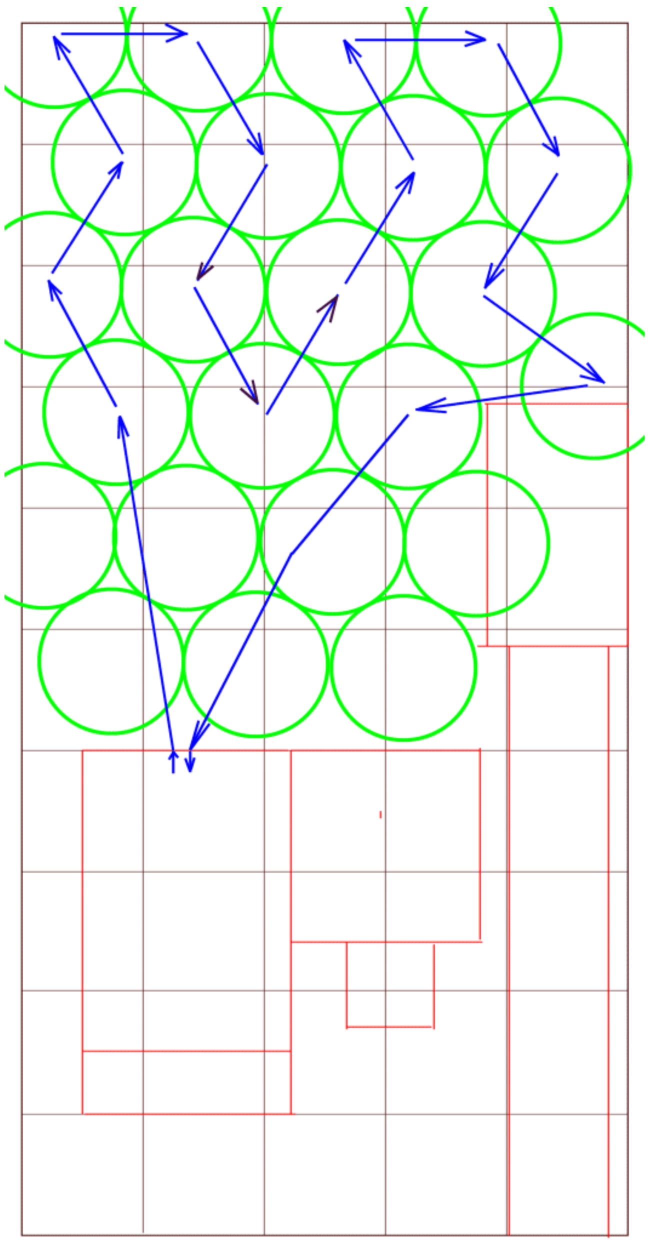
I can now report that when comparing welded connections to barbed connections,

Welding is cheaper
Welding is easier
Welding is more durable
Welding is faster
Welding is more likely to yield a leak-free connection

The choice is pretty clear.

Loop Field Hook-Up...

Here's a diagram of my Loop Field...



...as you can see, I planned for more loops than I actually put in.

If I need to, I can add more loops in the future. There's even room in the front yard for maybe 6 additional loops. During the summer, I measured the pavement of the street in front of my house, and it was 145 degrees F on the hottest day. Some serious heat under that street, and with my name on it too!

I arrayed the boreholes as I did to get them as close as possible, like how honey bees arrange their cells. It allowed me to pack more holes in the space I have, but it really made trenching more difficult. If I had more space to work with, I would definitely put them in a grid pattern.

The hook-up sequence was arrived at because I wasn't sure how much pressure would be reduced by stringing all the loops in series. As I have it, I can cut in after the 8th loop and re-connect the field as two branches, each with 8 loops.

It's much simpler with one loop, but if I can't get the flow rate I want, I may change it in the future.

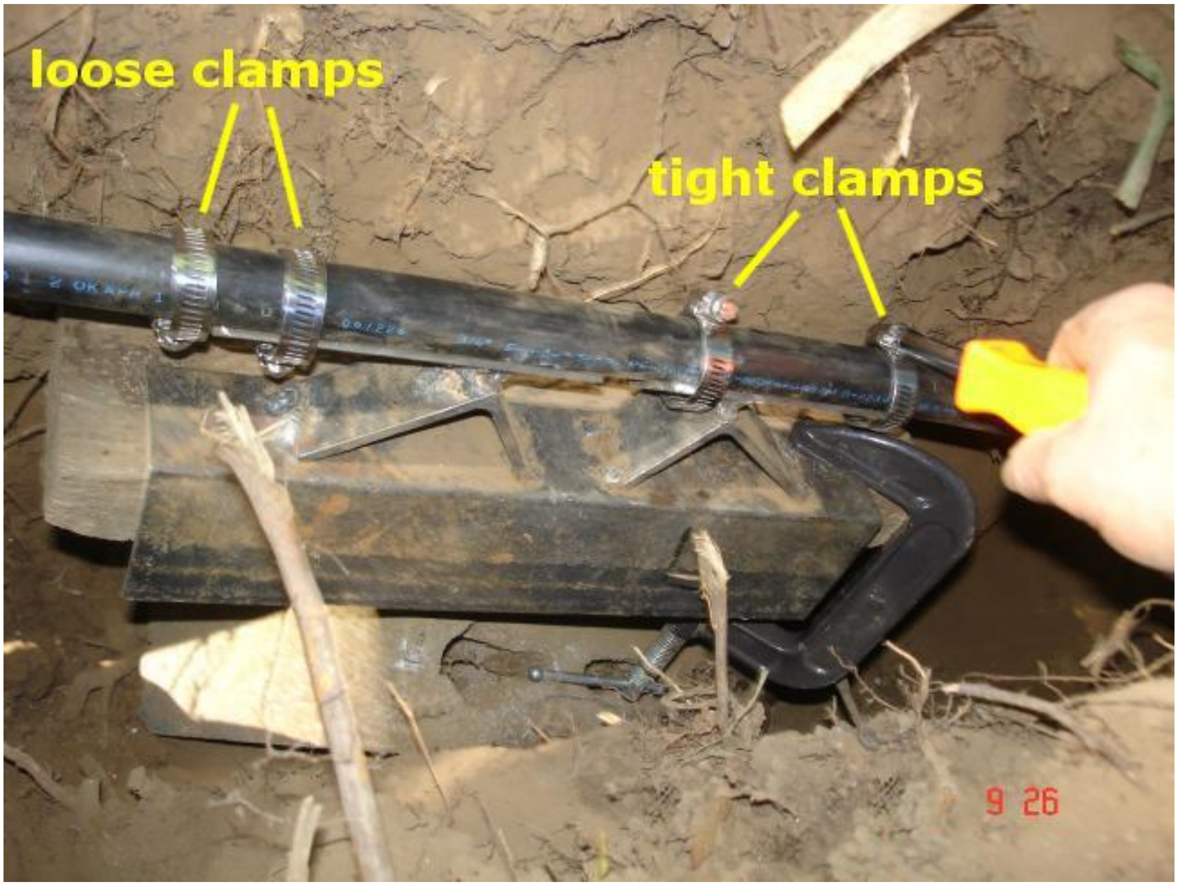
Here's the loop field after trenching, before connecting all the loops:

I found that it really pays to run the trencher as close as possible to the plastic pipe, without hitting the plastic. Making corrections for a wide space (I had many) has been very time consuming.

Also the trencher threw the dirt up just over the edge of the trench and quite a bit fell back into the trench. The trusty Rigid shop vac was the perfect tool for clearing out the trenches and reclaiming those precious extra inches.

As I stated previously, I though I'd need to use barbed connecctors in the trenches, but later realized that I could pull the pipe up tight, weld the connection, working just inside the trench and then push the pipe in and cover it while holding it down with anything heavy (like large stones or my foot).

Here's a pic of the welding jig as I used it in the trench. I put a cinder block under it to hold it up. By tightening the hose clamps on one side of the jig and leaving them a bit slack on the other side, I was able to free up a hand which I'd then use to hold the fusion paddle.



After each weld, I'd let it rest for about 5 minutes, then I'd fill it up with water and gradually introduce air pressure to 90 psi. This should be done gradually, because if you hit the water filled tube fast, it gets the water moving pretty quick which can exert much more than 90 psi on the branch under pressure. I didn't do it, but I'm pretty sure that it would be possible to rupture a water-filled branch by pressurizing it too fast. I think this is referred to as "Water Hammer". I tested every weld, every time. Leaks were very easy to spot, water was spraying out of the few bad welds. Using a water bath method and looking for air bubbles to find leaks was out of the question.

Here is a pic showing two welds:

The top weld is a nice looking weld, the bottom one was done in a hurry and looks pretty crappy.

However, when I filled them with water and pressurized them, they both held just fine.

That's what really counts.

Here's a picture of the backyard.

The loop field is complete, it's fall, the leaves are falling on the buried loop field, nature is healing her scars. It's raining every day now.

I just wanted to finish off the loop field installation thoughts and then move on to hacking the air conditioner...

Now that I have done it, I have to say that it sure was a lot of work, to put it mildly.

If you live in an are where there is a sand/clay mix and no big rocks, the mud-drilling method is a great way to go. But the mud drilling method is not suited to rocky ground.

If you have the land, and access to a backhoe or bulldozer (rent them), the trench & slinky method is a good bet, but certainly not suited to hand digging.

If you live on a small lot like me, vertical is really the only choice.

But I do realize that if you need to go vertical and have no access to heavy equipment and aren't likely to buy or build your own power auger, hand digging is possible, soil conditions permitting. A combination of a hand-turned post hole auger that allows water-pipe extentions ($35) and a beefy shop vac, such s a Rigid 5HP, or bigger ($60) would work. If you set yourself the goal of one hole per week, it can be done (one day to dig, six days to forget how much work was involved). My boreholes were 17 feet deep when I hit rocks and then hardpan. I didn't sense that 17 feet was any kind of limit to the auger or the shop vac, once I switched to 2" ABS pipe (lower friction than small pipe). The deeper the better, soil conditions permitting.

Converting an Air Conditioner to a Water-In-Water-Out-Heat Pump

The Air Conditioner I have chosen is a small unit, that was in good shape, actually works and was cheap. As I recall, I bought it for $25.

What I'm going to do is to remove the air-to-refrigerant heat exchangers, and in their place I will put some water-to-refrigerant heat exchangers.

This will involve:

1. cutting into the hermetically-sealed refrigeration circuit
2. capturing the refrigerant that is in the system
3. brazing the new heat exchangers into place
4. testing the system for complete hermetic seal
5. pumping out all of the air/water vapor that entered the system in the above process
6. re-charging the system with refrigerant
7. testing and adjusting as needed

There may be a few side-trips in the process, but this is the general road map I'll be following.

I have done this once before as a test, to see if I could actually work with this technology. The results were very encouraging, so much so that I'm now going to build a unit that I intend to use as a heat source for my house.

I started a thread previously that can be found here. This previous thread covered general operation of a vapor-compression refrigeration system and plenty of views of the airconditioner I'll be modifying.

There will be some tools and skills you will need for this process and I'll call them out as we go.

One of the general ideas here is that you want to have the tools and skills, and parts you require, on hand before you start. You don't want a refrigeration system to stand open, exposed to air and water vapor any longer than absolutely necessary. You will want to open the system, capture the efrigerant, remove the old parts and install the new parts in quick succession.

Another general idea is that this is not designing a system from scratch, but rather re-purposing an existing device. So there are parts in the system that you will want to handle carefully, as you will be reusing them, like the capillary tube(s).

* * *

DO NOT SILVER SOLDER REFRIGERATION EQUIPMENT, BRAZE IT.

You will be brazing the system back together once it is opened, so you should have on hand the equipment and skill for brazing before you open the system up. In some of the vapor compression hacker forums, I have heard of people using propane tourches to do refrigeration brazing. This was how I began, and it was very frustrating. I also started out using phosphor-bronze brazing rod because the price was very attractive, but still no love. Finally I got some silver-alloy brazing rod and a MAPS tourch and things began to work for me. The percentage of silver in the brazing rod really affects it's melting and flowing characteristics, and price. I have seen 5% silver rod, 15% silver rod and 40% to 55% silver rod. This stuff is really expensive the more silver, the more money. I was able to get a small amount of 56% rod and with the appropriate flux, it worked beautifully with MAPS gas.

...not pictured is the silver brazing flux, I need to get some more.

Here's a link to a brazing discussion from a HVAC blog:

Mapp gas for brazing??? - Refrigeration-Engineer.com forums

...and another:

Brazing material for refrigerant lines - Shop Floor Talk

Do some research, get to know your local refrigeration and welding supply folks, pick up some equipment and do a bit of practicing.

Heat Pump Brain Box???

An inexpensive controller with a web interface has been found.

I have examined the controllers from a de-humidifier and an air conditioner and I have found that they each look for some control temperature and when it is reached, they cut power to the compressor.

In the case of the de-humidifier, there was a circuit board and one thermistor that had leads that went to the circuit board. The thermistor was fastened firmly in place to the copper tube that went to the evaporator. When the evaporator got to a cold enough temperature for frost to form over most of the evporator's fins, the power to the compressor was cut. This allowed the hot refrigerant that was in the system to migrate to the evaporator and quickly melt the frost. When the temp got high enough, the power to the compressor would resume. This cycle continued until the container that captured the melting frost from the evaporator, got full, and power to the unit was cut, until someone came and emptied the container.

The control for the air conditioner was similar, but it was mechanical instead of electrical. Again, the sensor, which was some kind of metal 'bulb' was fastened to the fins of the center of the evaporator and when the temp got sufficiently cold, the power to the compressor was cut. When the temp got high enough compressor power would resume. On the air conditioner, the water from the melting frost was allowed to drivel out the back of the unit, and the unit would continue to run until the power was manually turned off. It was interesting to me that the temperature of the air was not measured, but rather the temp of the evaporator.

In my experiments, I stripped out the controller altogether. I learned very early that the heat pump has the ability to remove heat (BTUs or watts) at a certain rate from a heat source.

If the rate of heat transfer from the heat source is lower than the rate of heat extraction of the heat pump, a freezing water condition in the heat exchanger will occur. This would surely damage the evaporator heat exchanger.

I did reach this freezing water condition, but I was sitting right there as the water spectacularly and almost instantly turned to ice. I was able to yank the cord before damage could occur.

If the rate of heat transfer from the heat source is higher than the rate of heat extraction of the heat pump, the freezing water condition will never occur.

As things now stand, I calculate that the heat pump I am now building will extract heat at about the rate of 1600 watts (5459.2 BTU/hr), the rate of heat transfer from my loop field should be about 3940 watts (13444 BTU/hr), so I might not need the freezing water protection circuitry. On the other hand, if for some reason, the water leaked out of a loop, or if a circulation pump failed to operate, I'd have a serious problem on my hands. So I believe it would be a good idea to monitor the refrigerant line going into the evaporator heat exchanger, similar to what I found in the de-humidifier. And if it got too cold, it would cut power to the compressor.

Also, in the room that I will heat, I will want to monitor the temperature, and when it gets to the level of comfort I wish, it would cut power.

There are other conditions I may want to monitor, but those are the ones I can think of right now.

Ward-the-Wiki-guy has volunteered to help me make performance information available in real time on the Internet. Here is a photo of the electronics I have purchased to make this possible:

I got both of these boards from Spark Fun. The on on the left is the Ethernet Shield and the one on the right is the Arduino board.

The Arduino board is a microcontroller board, it will monitor several 1-Wire temperature sensors. The other board will interface the Arduino to the Internet. Ward has a similar setup monitoring certain aspects of his home, so what I'll be doing here is very similar. I'm pretty sure that the Arduino will be able to monitor and respond (cut power) if certain 'out-of-bounds' conditions occur.

At this point, I don't know much about the Arduino, or power control, but there is a community of talented tech-types that meet regularly to drink beer and swap stories and info. I've been going to the meetings and sharing what I'm doing with the Homemade Heat Pump Project, to great interest.

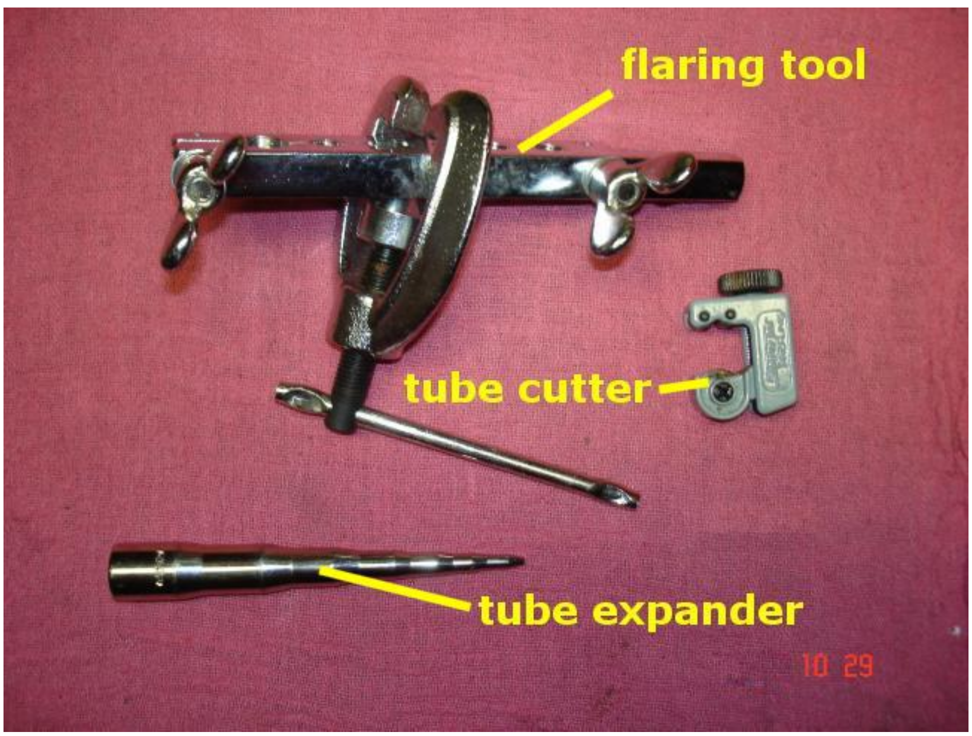
So that's the controller story at this point.

Brazing (Part 2)

My brazing skills went a bit rusty over the summer, so I thought it would be best to get the tools and skills ready to go so I can get on with the conversion.

In part 1, I showed you the MAPP gas tourch I'm using. As I said previously, I tried Propane, but it just didn't get hot enough to do the job. Mapp gas burns hotter than Propane, but not as hot as Acetylene. If you already have Acetylene, use it. If not, MAPP is good enough, and the setup is way cheaper.

So, in addition to the tools previously pictured, here are the tools I'll be using:



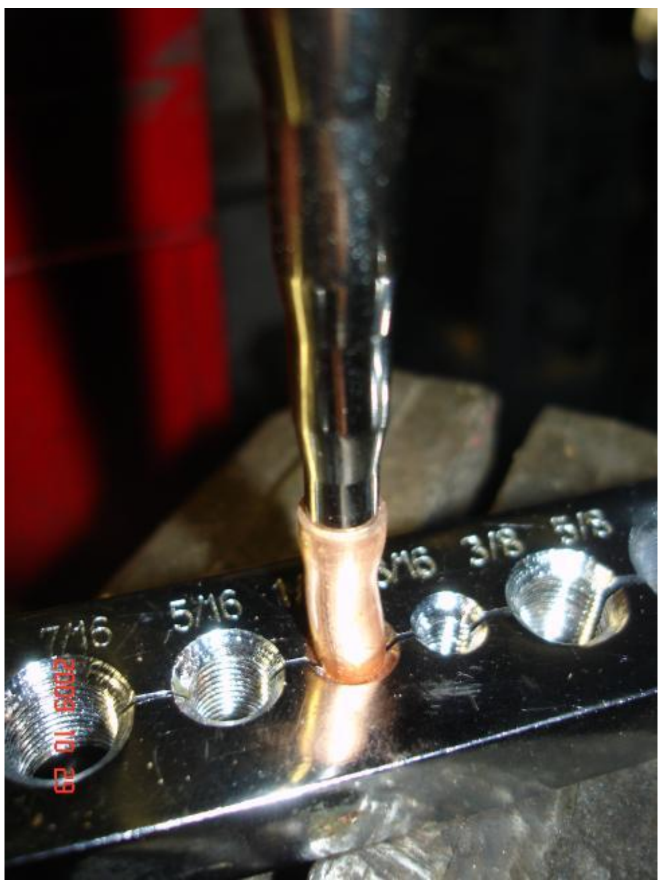
The flaring tool is usually used for making the flare for a flar fitting, but in this session, I'll be using it as a vice and as a heat sink.

The tube cutter is standard, but I know I'll be working in tight spaces, so the small kind is best.

The 'tube expander' probably has a much better name, but I'll be using it to expand tubing.

One joint we will need to make will connect two pieces of tubing of the same size.

Since refrigeration is subjected to vibration, a butt joint will not do, so the trick is to expand one piece of tube so that the other tube will fit inside.



Here I'm using the flaring tool as a vice and I'm tapping the tubing expander with a hammer to stretch the tube to the right size. I'm actually going two steps bigger, so the tubing got a bit deformed, but it ends up being a sound joint.

Here I'm applying silver-brazing flux to the tube that will slip inside.

Now we give it all the heat that MAPP gas has to give...

I have noticed that I am much less timid about applying heat than I used to be, and my brazing is all the better for it.

So now, let's see what we have...

So here's a photo under the microscope of the braze joint I just did:

So, here we are, this was done with 55% silver brazing rod. Horribly expensive stuff, but it works like butter.

So, I cut the brazed joint off and I noticed a little black flake sticking out of the tubing:

So all the lovely heat of the MAPP gas has caused the copper in the tube to combine with oxygen and make this flake of copper oxide. This is **VERY BAD** for refrigeration, because the refrigeration circuit relies on liquid refrigerant passing through a capillary tube or a tiny orifice to regulate the flow rate. Just one flake of copper oxide could ruin the whole thing.

* * *

Another joint we will need to master is joining a smaller tube to a larger tube:

Here's how we do this one...

We put the smaller tube into the bigger tube and grab the edge of the big tube with a pair of pliers, and pinch...

...and pinch really hard and you've got it!

Now let's put some heat to it...

The brazing rod I've been using is 55% silver. It cost me $20 for two ounces. Pretty expensive stuff. Around here they won't sell 5% silver or 15% silver in amounts smaller than a pound, and it costs $35 and $70 per pound respectively. But if you're only going to do a very small amount of brazing, $20 worth of brazing rod might be enough, and still it would be the cheapest way to go.

When I stopped off to see Bruce-the-pirate today, he gave me a stick of 5% silver brazing rod to try. I was pretty sure that it was going to be an absolute failure, but I decided to give it a try anyway.

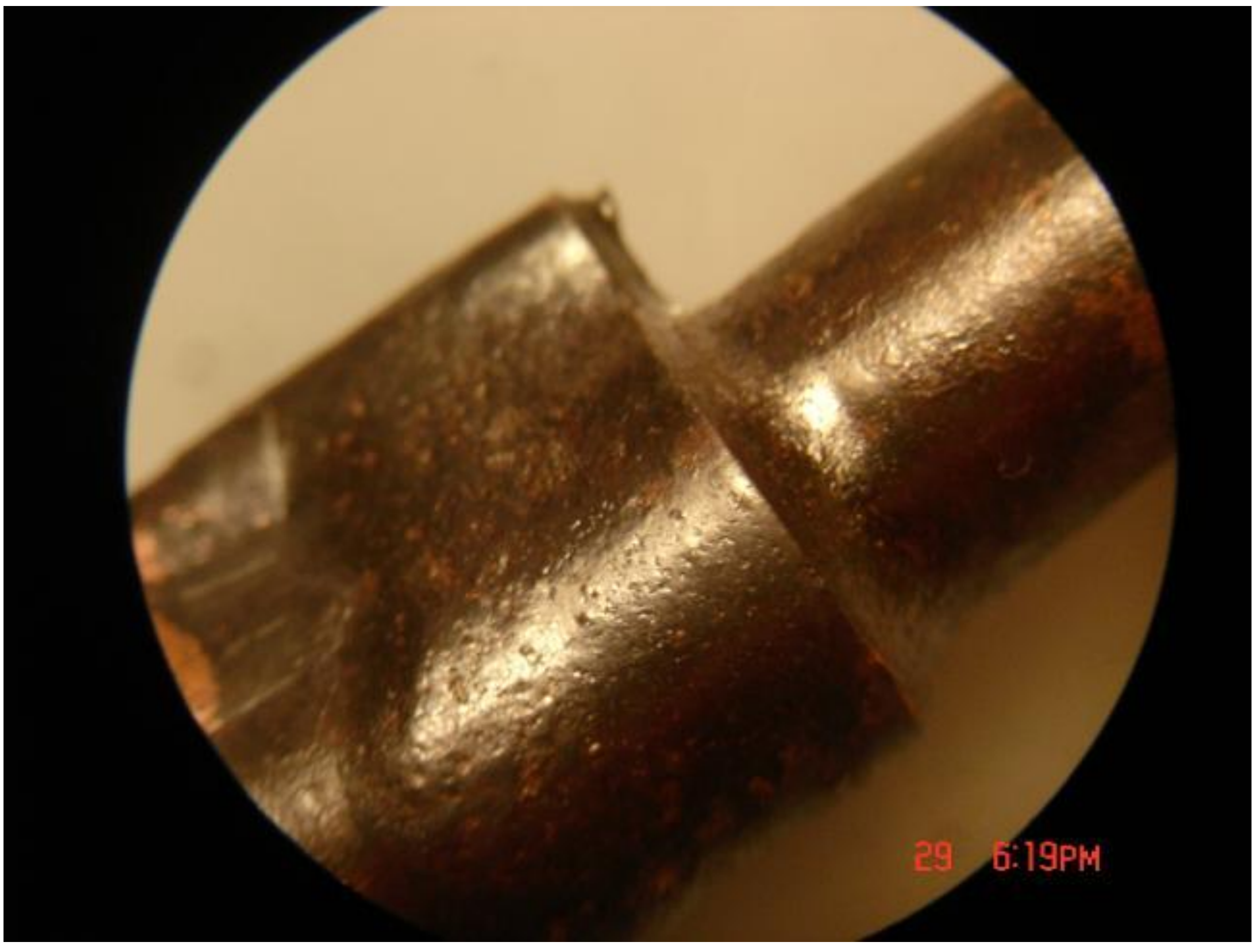
So I fired up my tourch and leaned the flame into the joint I had formed.

Like I said, I have become much less timid at applying heat, compared to myprevious experience.

The 5% silver rod, and the 15% silver rod have a phospher-bronze alloy which is self-fluxing when joining copper-to-copper.

When I applied the 5% rod to the cherry-red joint, I was completely amazed, very fast melting and a very nice flow. It just took one small touch-up on the back side of the joint to make a good braze joint, all around.

Here's the microscope photo:



...but when I cut the joint out, all these black flakes of copper oxide fell out too. This will never work for refrigeration.

Something has to be done...

PLEASE NOTE:

* * * This procedure is dangerous by nature * * *

This procedure uses propane gas instead of nitrogen. Nitrogen is used in the HVAC industry because it is non-flammable and relatively safe. When propane is mixed with oxygen, it becomes dangerously flammable. If you already have access to nitrogen, or another inert gas, you should use it instead of propane.

*** * * This procedure is dangerous by nature * * ***

The brazed joints were looking pretty good, but there were horrible problems with the little black flakes of copper oxide that had formed outside, but more worrisome, inside our brazed tubes.

The flakes were caused by oxygen combining with copper at high heat.

Daox suggested using a vacuum pump to pump out the air before we brazed. Good idea, if we could vacuum inside and outside the tube, it would work, but otherwise, we'd have a strong stream of air streaming through our brazed joint.

The common practice in HVAC work is to use an inert gas, usually nitrogen, to displace the air. Someone suggested carbon dioxide. I know it is cheaper than nitrogen, and is sometimes used in welding, but doesn't seem to be used in refrigeration brazing, despite its economy.

So I trotted down to the welding store and added up the equipment:

- nitrogen tank = $115
- nitrogen gas = $15
- regulator = $110
- hose = $20

That's $260 to chase away tiny black flakes.

So I remembered that some idiot tried propane as an inert gas for welding. Well, I sensed that I had some natural kinship to that guy so I decided to give it a try. Here's what I came up with:

First I unscrewed the flame tip from the propane torch, which was worthless for brazing anyway.

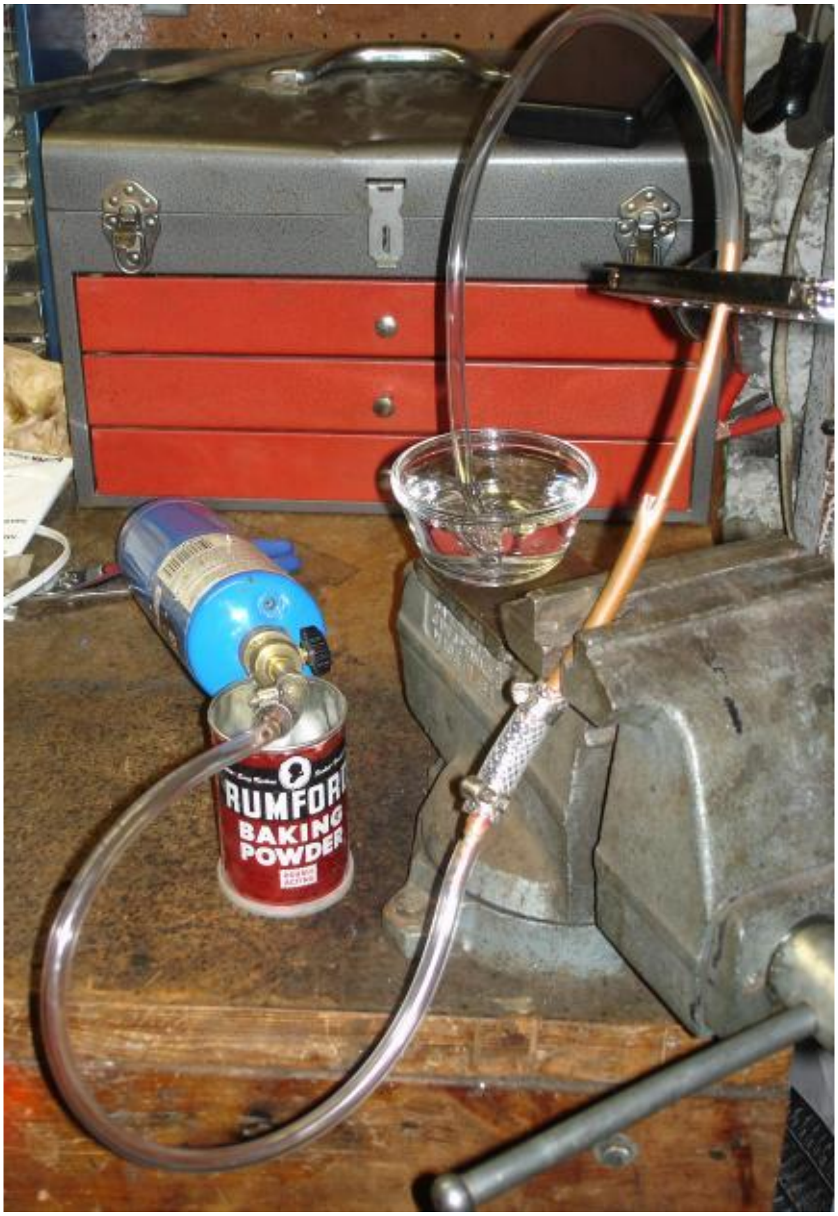
Then I used a 3/8 inch ID plastic tube.

Next, I used one of the 3/8 to 1/4 reducers that I made when I was practicing my brazing.

Then came some 1/4 inch tube. The reason for all this is to reduce the volume of the gas as much as possible.

I also made another 3/8 to 1/4 adapter for when I want to hook up to 3/8 inch tube.

So here's the whole setup:



The gas from the propane bottle feeds into the tubing, via adapters to the tube to be brazed. The vice acts as a heat sink, but not very well. I may get another cheap flaring tool to use as a heat sink because the one I have over the brazed part is working very well. More surface area around the tube to carry off the heat. Finally, the tube from the other end of the brazed part goes into a dish of water, to act as a flame trap and also as a visual indicator of the volume of gas that is flowing.

So the way I did it was first to make sure that the windows were open and that there was no flame or pilot light or spark source or nearby flammable material that could be a problem.

Then I cracked open the propane bottle and let the propane bubble vigorously for a few seconds to purge any oxygen out of the line.

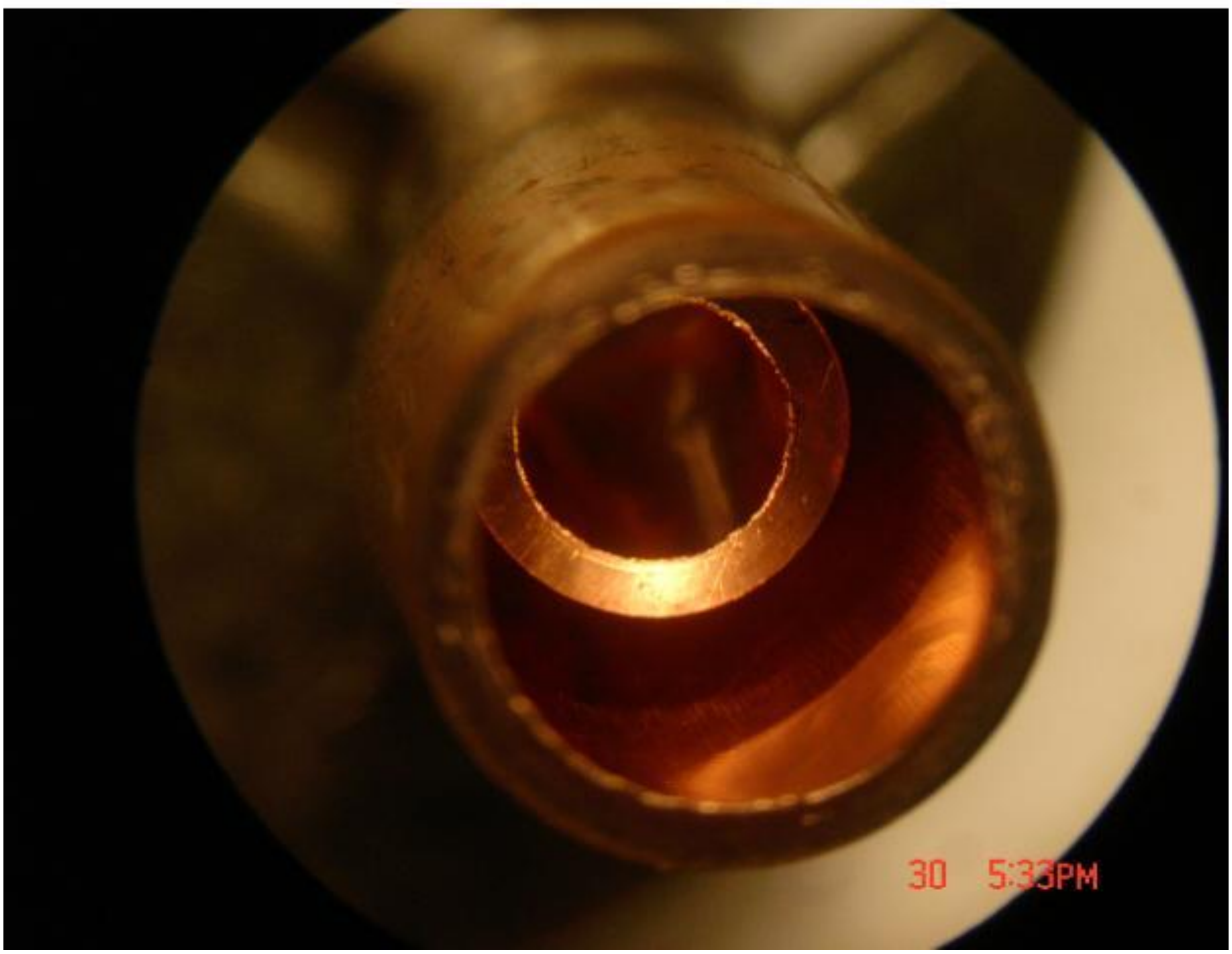
The I reduced the flow of the propane until there was a bubble every second or two. I allowed about ten seconds for any local concentrations of propane to dissipate. Then I fired up the MAPP tourch and started to braze as usual, this time I used 5% sliver rod. I was expecting to see a small flame near the joint I was going to braze, but I saw no flame at all. I did see a small leak where the plastic tube joined with the copper. I extinguished the MAPP torch, and blew the leak flame out quickly and added the small hose clamp at the leak point. Then I repeated the purge procedure, then the reduction in flow, then the 10 second wait.

This time the brazing worked just fine, not leak, no problem...

NOTE: BE SURE TO TURN OFF THE PROPANE BOTTLE AS SOON AS THE JOINT IS BRAZED. OTHERWISE, TERRIBLE THINGS CAN HAPPEN.

And here's the result:

Top photo shows the tube cut open, I banged on the tube for all I was worth with a screwdriver, trying to dislodge any tiny black flakes... As you can see, there were none.


30 5:33PM

Bottom photo tells why... This is a microscope shot down the barrel of the tube I just brazed. The cut was made about 3/4 inch from the brazed joint and about 5 minutes earlier, it was glowing cherry red. As you can see, there is no copper oxide, not even any discoloration.

Problem solved.

...also here is a YOUTUBE video on the same topic. However this guy who is brazing is using Nitrogen gas to prevent copper oxidation. Much safer practice!

http://www.youtube.com/watch?v=3uP-eb8Zz08

Other gases as CO2 or Helium may work as well.

Now that I have done a bit of brazing practice, and have found a way to prevent the copper-oxide from forming inside the brazed refrigeration lines, I think I'm all ready to go. I have my heat exchangers ready and it's time to strip down the AC unit and see how everything's going to fit up.

If you haven't tackled anything like this before, it's good to cultivate a calm and peaceful mind before beginning.

I like to get a hot cup of tea, a notebook to take notes in, a digital camera to take photos for future reference.

So find a fairly sturdy surface to put the AC unit on that is at a comfortable height. Since my workshop isn't very much bigger than a phone booth, I set the AC unit on my little freezer.

You'll need a phillips screw driver with a plastic handle and some pliers, preferably with plastic-covered handles, to get most everything apart.

(* MAKE SURE THE AC UNIT IS NOT PLUGGED IN *)

First we carefully remove the metal and plastic panels. I like to save all the screws in a jar lid either for re-assembly or future projects. If a panel refuses to come off, there's most likely a screw hiding somewhere. Be patient, don't force anything.

So the bottom pic shows my AC unit minus the panels.

So, take a few minutes to just look at the unit from all angles. After all, you paid good money for this thing (I think I paid $25), and it may never look this way again...

One of the ideas I like to consider is ***the possibility of obtaining the maximum amount of benefit with the minimum amount of modification***...

In my case, I have decided to make a water-to-water heat pump out of an ait-to-air cooling device, so the modification will be significant.

But we could make an air-to-water device to pre-heat water for a water heater. If we went that route, we could leave almost all of the unit intact and just replace the condenser (the tubing with the fins on the back that get hot when the AC unit is running). We'd still have to extract the refrigerant, cut out the existing condenser, and braze in a refrigerant-to-water heat exchanger. We'd also probably want to remove the rear fan, since it would no longer have a function.

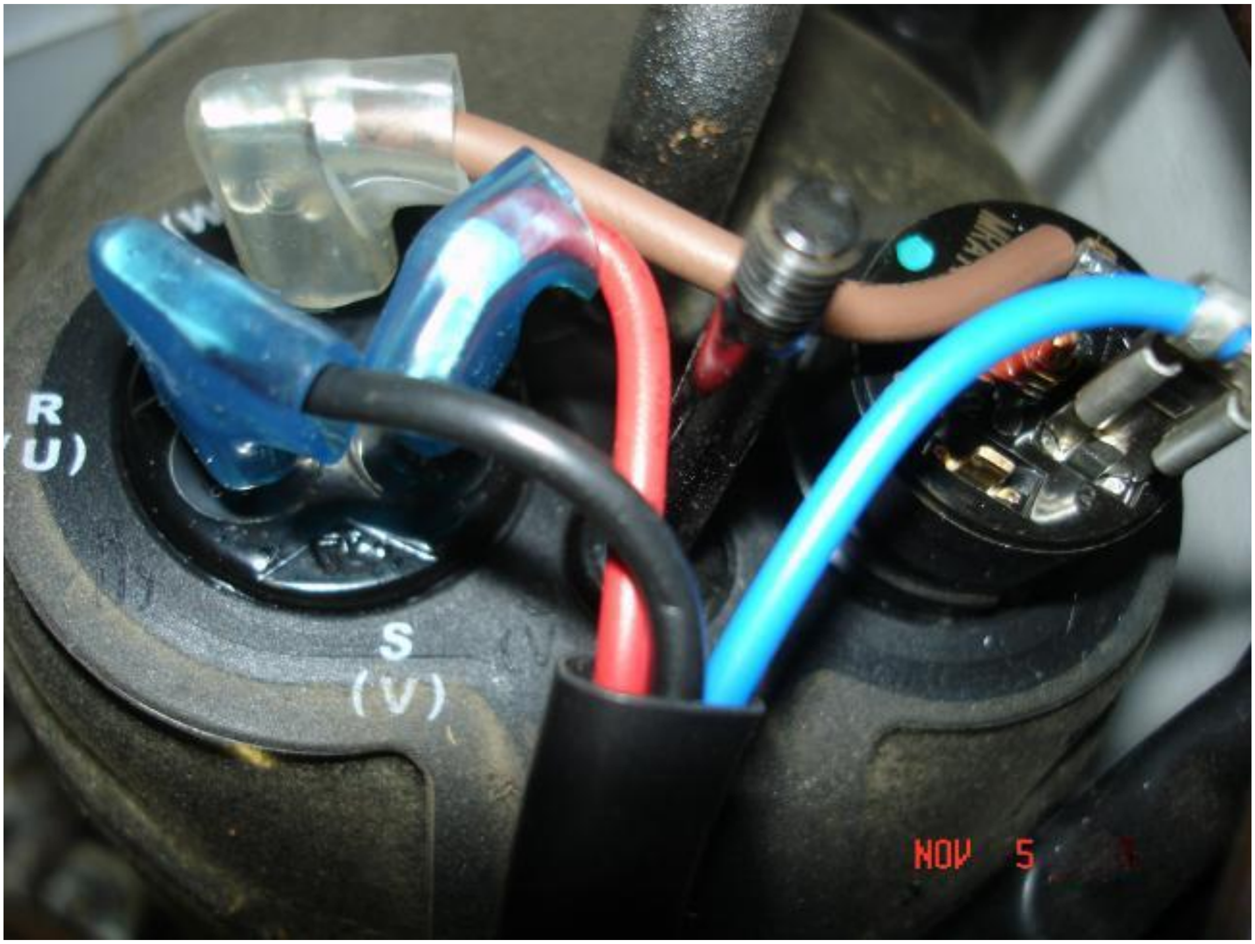
There are other possibilities too, to be considered.

(* EYE PROTECTORS SHOULD BE WORN FOR THE NEXT SECTION *)

Now let's look for the capacitor. It's usually silver, about the size of an orange juice can, and has wires sticking out of the top. The purpose of the capacitor (AKA: 'cap') is to store electricity for the compressor and motor to start. There's a good chance that the cap still has enough voltage stored in it to give you a nasty shock. **(* The reason for the eye protection is that if you get a shock, the tool you are holding could get involuntarily jerked in the direction of your face *)** Get a plastic handled screw driver and short the connectors together. There are usually three of them so it may take a bit of finagling...

Now we are going to carefully remove the wiring assembly. They are all different, so I can only give general directions.

On top of the compressor, is a plastic cap with a small nut holding it on. Get a small wrench or pliers and remove the nut, and the washer under it. As you remove the nut, notice how much force was required to remove it, usually not very much... remember that because when you put it all together, you won't want to use too much force. Put the nut & washer in the same place you carefully put all the screws. Now carefully remove the plastic cap. You should see something like this:



Your wires might be a bit different. This is the time to get the digital camera out and photograph the wire positions, from several different angles. Also a good time to get the notebook and draw a picture of the wire positions, including any little letters that may be printed near the wire terminals and the colors of the wires that attach there. I promise you that there will come a time when you will want **both** the photo and the detailed drawing. Now it's time to remove those wires. This is where the rubber-handle pliers come in. Did you already short out the cap? Because some of the wires from the cap go to the compressor... So firmly but gently grip the connectors and pull straight up, one at a time.

Some of the wires will go to the capacitor, which might be out in the open. So, you will want to pull those wires too, but not before you make a photo and do a drawing, labeling any colors and markings on the cap for future re-assembly.

Also, some of the wires will go to the switches on the AC unit. It's time to remove any screws that holds the switch. There will also be a tiny tube from the switch that goes toa little tab in the front of the evaporator the part that gets cold when the AC is running.

At this point, most all of the wiring should be easy to remove, maybe a screw or two, but it should come right off...

Here's what my wireing assembly looks like.

It would probably be a good idea to put the plastic cap and washer and small nut back on the compressor and snug it down, so it doesn't get lost.

So, here's the compressor minus the wires:

Notice the small coil of very thin tubing that is near the bottom of the compressor...

This tiny coil is called the 'cap tube', no relation to the capacitor...

This tiny coil is very delicate and serves the purpose of precisely metering the refrigerant from the condenser (hot part) to the evaporator (cold part). We will need to re-use this delicate part, so be very careful with it, don't bend it if you can possibly avoid it, and if you kink it, then **GAME OVER**. We will be cutting the tube somewhere around the yellow marks, but that will be a bit later. For now, be very careful around the cap tube.

Refrigerant Extraction... Installing a 'Piercing Valve'

To allow the capture and storage of the refrigerant. I have used a re usable piercing valve before, but I wasn't able to find it, so I went down to the neighborhood refrigeration supply shop and picked up the only one they had which was a braze-on model.

This valve has a removable core, with a tiny plastic gasket, and a brass screw-on cap. The core must be removed, then the piercing valve body is brazed into place on the still-pressurized refrigerant line, then the core is inserted and the cap is screwed down tight, driving the point of the core through the refrigerant tubing.

(* * * The core is removed before installation, because the heat of brazing will destroy it. * * *)

Notice that I cleaned up the tube where the piercing valve will go, this makes brazing much easier. The coreless piercing valve is placed over the tube and a pair of pliers is used to snug the tabs around the tube.

I put some flexible fireproof kiln material that I bought for this purpose, around the area where I will be brazing, to protect everything from the intense heat.

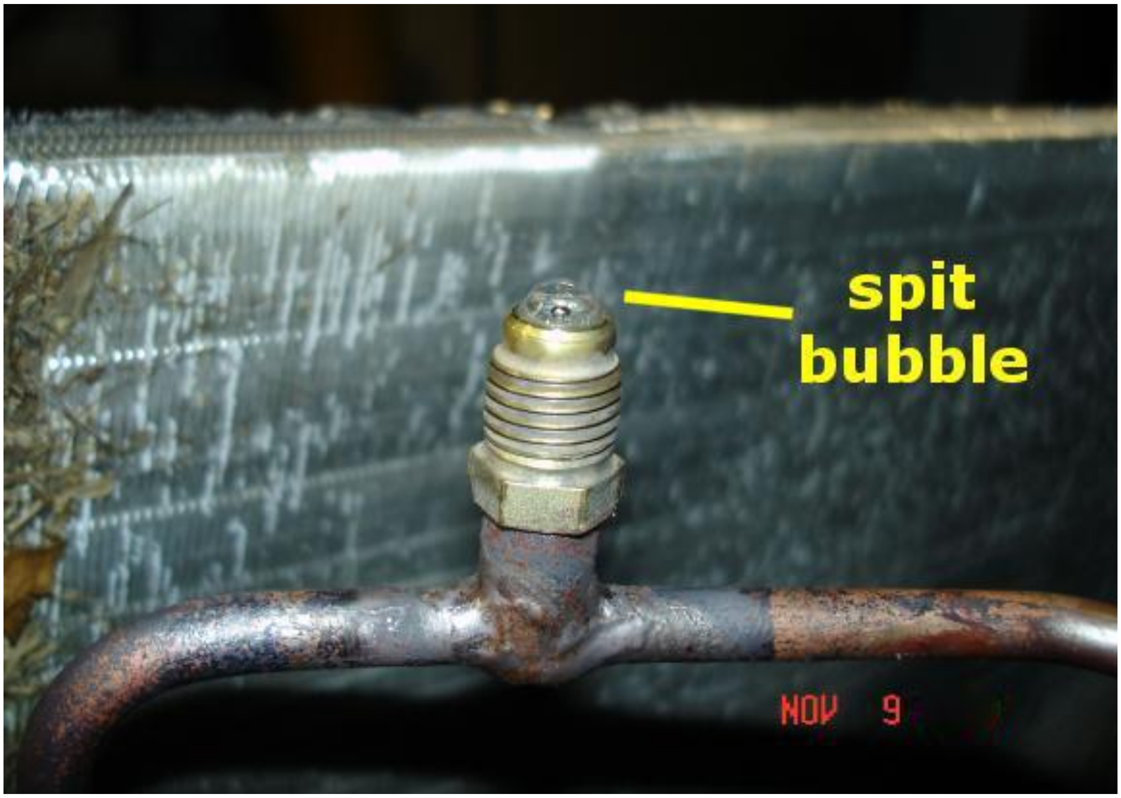
Since my last very positive experiences with 5% Silver-Phosphorous brazing rod, I have been using it exclusively, with no flux, with very good results.

Once the copper was glowing cherry red, I touched the brazing rod to it and it flowed around pretty well. I needed to do a wee bit of touch-up at the bottom, but it went much easier than I thought it would.

So I waited several minutes, until I could comfortably hold on to the newly brazed piercing valve.

Before I put in the core, I pulled a vacuum with a micron gauge attached, and quickly hit 330 microns, so I took that to be 'no leak'.

Next, I removed the vacuum hose, and inserted the core with its tiny plastic gasket. Then I put the brass screw-on cap in and cranked it down with two small wrenches of appropriate sizes. This is the point when the core actually pierces the refrigerant line. There was no hiss or leak sound, or any sign of refrigerant oil to be seen.



However, I did put a little spit over the end of the valve, and sure enough, it formed a bubble... slowly, but a bubble. I also noticed that the valve was becoming suspiciously cold, so there was a very small, slow leak happening...

I suspect that if I put a small neoprene 'O-ring' inside the brass cap, and use assembly lube on the O-ring and also on the threads, I could probably stop the leak, but it was not a confidence builder.

But it still give me a way to hook up my extraction equipment to the AC unit and extract the refrigerant, which was the whole point.

So, I screwed the brass the cap on, and set about, getting my refrigerant extractor equipment ready...

Refrigerant Extraction, Making a Small Extraction Tank

When we extract the refrigerant, we can't just let it drift off into space. In addition to being unlawful in many parts of the world, it is immoral in all parts of the world, as commercial non-organic refrigerants will cause global warming and/or destroy the ozone layer. This has adverse impact on all life, no matter what country you live in.

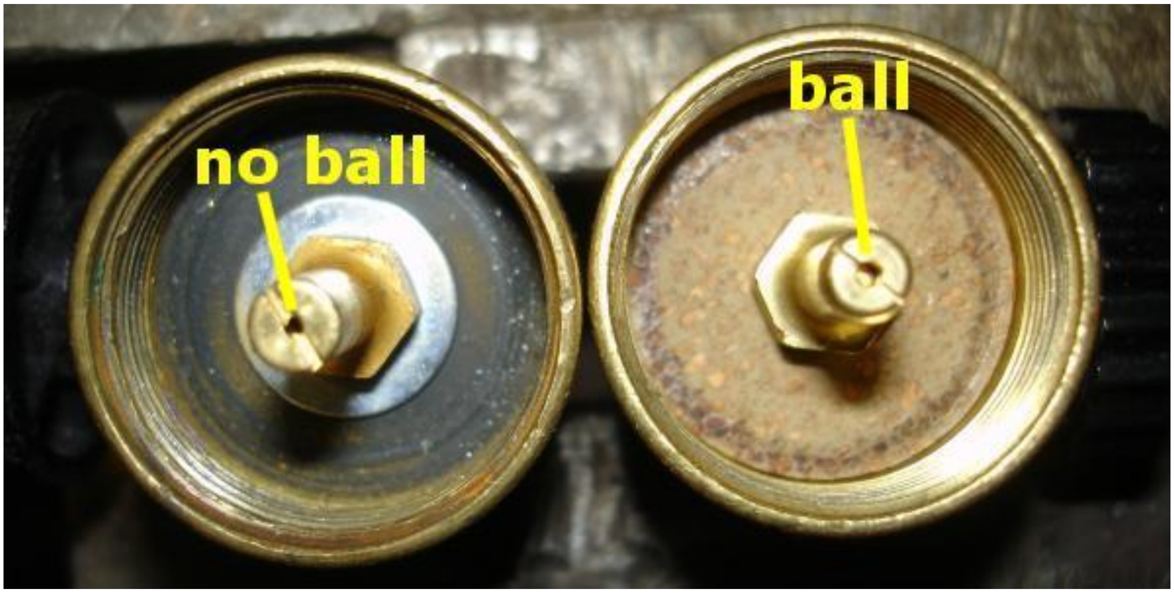
So we need to make an 'extraction tank' to store our refrigerant in, temporarily or longer. This will allow us to reuse the refrigerant later, or we can take it to be properly recycled.

Small AC units and de-humidifiers hold about a pound of refrigerant, which will fit handily inside an empty propane torch bottle.

So what I did was convert a propane torch, the kind that screws onto a propane bottle, into a refrigerant extraction adapter.

A few simple mods are in order:

To enable refrigerant to go into the empty propane bottle, we need to remove the tiny ball that is in the stem at the bottom of the torch.



I just unscrewed the stem and removed the ball, then put the stem back on, minus the ball.

Next we need to remove the too-small orifice from the torch...

The orifice is a small hole at the end of the torch tube. It is so small you might not be able to even see it. As I recall, I got some pliers and just unscrewed the orifice brass part and threw it away. (It could also be drilled out)

Then I temporarily removed the needle valve from the torch because the heat of brazing will destroy any rubber sealing parts, and then I brazed on a 1/4 inch Schrader valve (Also removing the Schrader core before brazing).

I didn't put the Schrader core back into the valve, because with the needle valve of the torch, there's not much need.

The Schrader valves are used in the HVAC trade and come in various sizes, with 1/4 inch being referred to as "standard". They are really a bike or car inner-tube valve core fitted onto a flare fitting, and usually soldered or brazed onto a copper tube. They aren't too expensive, and it's not a bad idea to get several, you'll probably use them all.

The propane bottle that we will use for our storage tank needs to be **really empty** of propane. If you shake it and can hear or feel any propane at all, there's too much propane. You should be able to put a known good, un-modified torch on the bottle, and attempt to ignite the torch in the normal manner, and be unable to light the torch because there is not enough propane. But, even after that, there is still propane in the bottle...

So only after the 'fails-to-ignite' test, we put our newly-created adapter onto that bottle, attach a vacuum hose to it, and turn on our vacuum pump, making sure that the needle valve is open, so the last remaining propane can be evacuated... let the vacuum pump run and watch the vacuum gauge go down to full vacuum, then let it run for an additional 10 or 20 minutes minimum.

Voilà!!, we now have a small, cheap extraction tank ready for service.

The beauty of using propane bottles is that each one has it's own ball-valve built into the bottle to prevent gas from escaping. When you remove the torch from the bottle, you can hear the ball-valve snap into place.

Make sure that when you recover your refrigerant, you don't over-fill the bottle. You want to leave a minimum of 1/2 to 1/3 empty. Refrigerant in the vapor state is compressible, but refrigerant in the liquid state is not. If a too-full bottle of refrigerant was allowed to get hot, there is a distinct danger that the refrigerant could expand and rupture the bottle, with unpredictible consequences... none of them pleasant. Stay on the too-safe side.

Refrigerant Extraction, Extraction and Storage

This section will cover the extraction and storage process.

>>
This Guide is aimed at an international audience. Some aspects of vapor-compression servicing and modification are regulated in certain geographical areas. Other geographical areas are quite free in this respect. The reader of this Guide is advised to find out what regulations may apply, if any, and act accordingly.
>>>

As previously stated, When we extract the refrigerant, we can't just let it drift off into space. In addition to being unlawful in many parts of the world, it is immoral in all parts of the world, as commercial non-organic refrigerants will cause global warming and/or destroy the ozone layer. This has adverse impact on all life, no matter what country you live in.

A refrigerant extractor should be used to capture and store the refrigerant. Such a device may be purchased new, purchased used, rented, borrowed or made by the reader.

Xringer shared this video link for those who may want to make their own.

These links may also be of interest to DIY recovery machine builders:

- how do i build a Refrigerant Recovery Unit [Archive] - XtremeSystems Forums
- DIY Refrigerant Recovery Machine! - Overclockers Forums

Relentless haunting of pawn shops and ebay may turn up a reasonably priced unit.

Luckily, Bruce-the-Pirate loaned me a recovery machine from his truly impressive store of tools.

The top photo shows the Microvac unit. In the upper right hand part of that picture is the grey filter that the input vacuum hose connects to. On the opposite side of the top is a fitting to which the outlet vacuum hose attaches to.

The bottom photo shows the vacuum hose connecting to the previously brazed Schrader valve on the AC unit.

The other end of the hose attaches to the previously evacuated storage bottle in the photo below. Notice that the bottle is in the deep freeze to help reduce the volume of the vapor inside the bottle. I have used bowls of ice water for the same purpose, it worked just fine.

The next photo shows the valve knobs on the Microvac.

Basically, they are both turned to the "Self Evac" position and the unit is run until a full vacuum is pulled, as shown in the top photo below.

Then the valve knobs are turned to the "Evacuation" position, and the needle valve on our storage bottle is opened. You will see deflection of the gauges as the refrigerant is pumped from the AC unit, through the Microvac, and into the storage bottle, as shown in the lower photo. The unit is run until the gauges indicate that all the refrigerant has been removed from the AC unit.

Then the needle valve on the storage bottle is closed and the Microvac valve knobs are returned to the "Self Evac" position and allowed to run until a full vacuum is again reached.

At this point, the microvac is turned off, the hoses are removed from the AC unit, the Microvac and the storage bottle.

Then the adapter we made previously is unscrewed. You will hear a 'snap' as the ball valve in the bottle snaps into position, sealing the bottle of refrigerant.

Then the storage bottle is put in a safe place, awaiting re-cycling or proper disposal.

So that is the refrigerant recovery process.

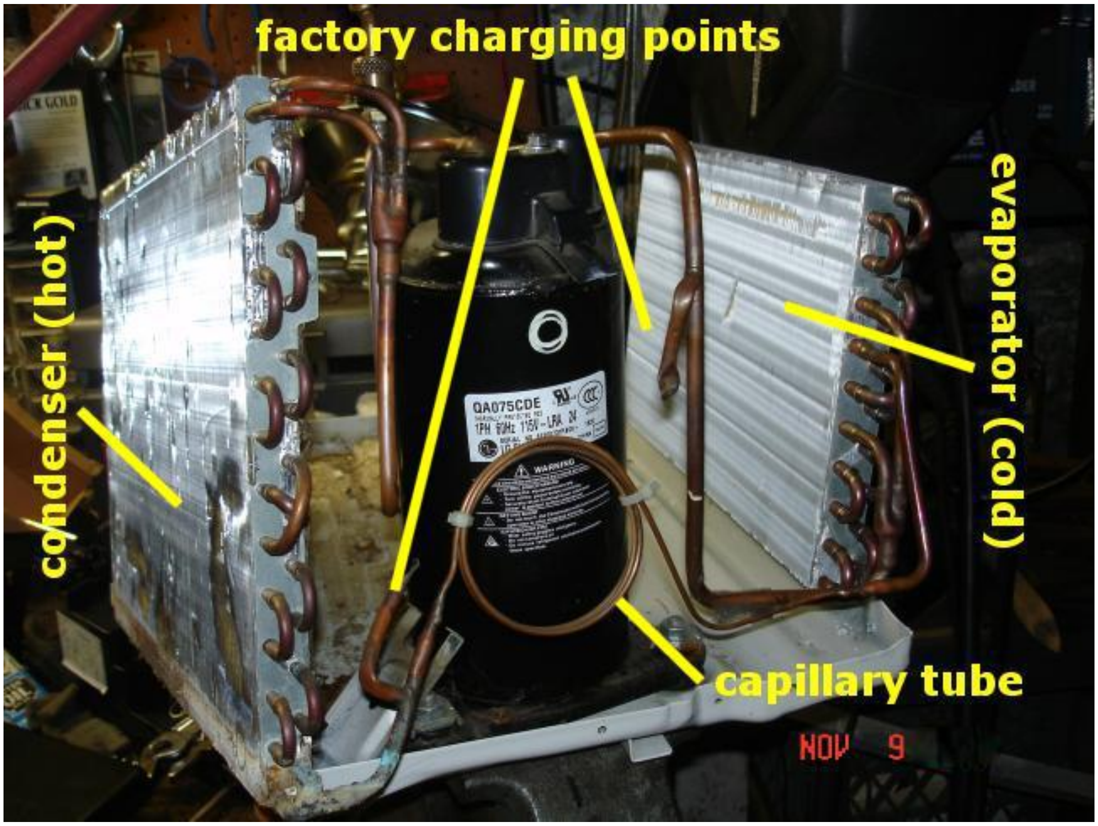
In our next posts we will complete the dismantling of the AC unit. Then we begin figuring out layout for the new machine, and preparing to braze up the new refrigerant circuit.

A/C unit Conversion, Final Dis-Assembly...

This post will cover the final dis-assembly of the AC unit, and the careful salvaging of parts for the new unit that we will build...

So after extraction, we can now safely cut away the pieces we will not need and carefully remove and set safely aside the parts we will need.

Here is a picture of what's left of my unit after extraction...

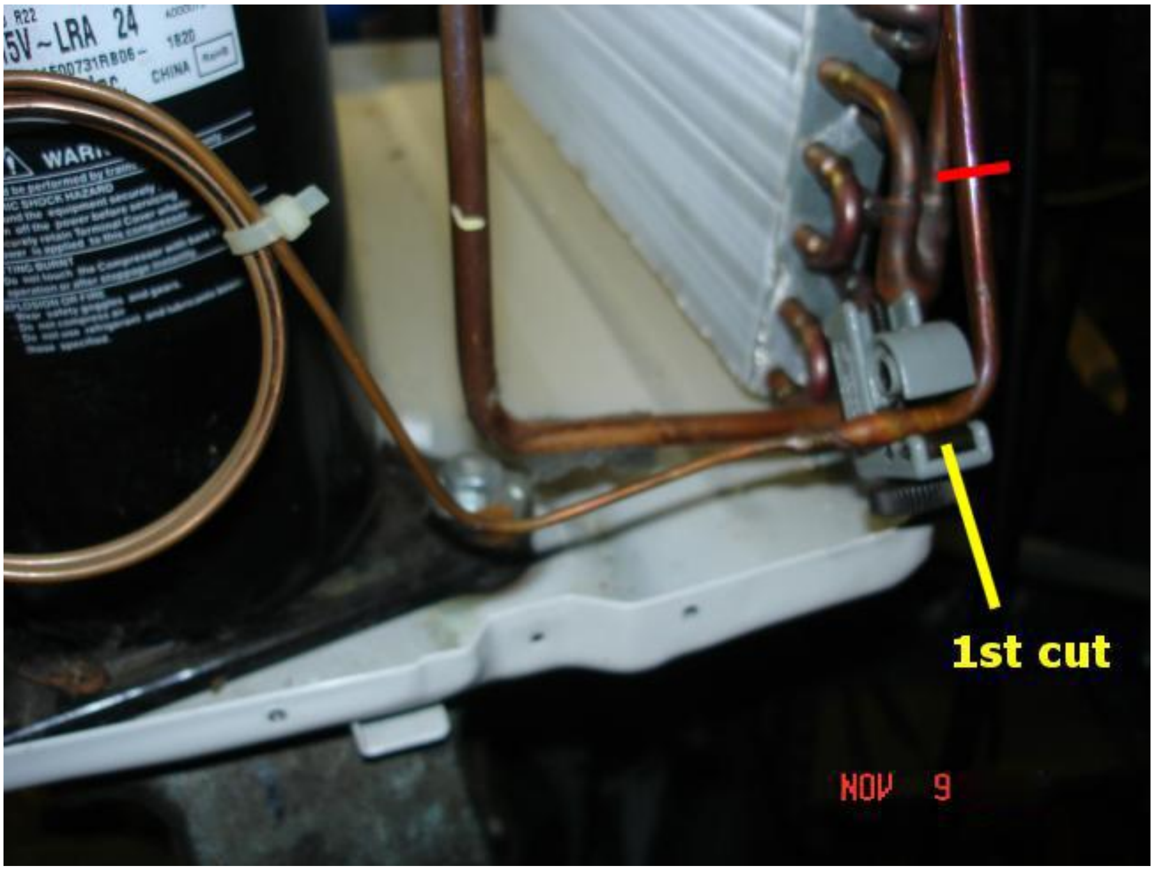


You can see the condenser on the left side and the evaporator on the right side. I'm not going to use them on this project, but they are in pretty good shape, and may come in handy for other projects in the future, So when I remove them I will be very careful to avoid bending the fins.

But we will carefully remove and re-use the capillary tube, as it is sized to work with the refrigerant & compressor, and re-using this aprt makes our job drastically easier. Cap tubes and metering devvices, and work by virtue of the fact that their diameter is of a precise size and their length is of a precise length to provide an exactly calculated amount of resistance to the flow of the refrigerant in the circuit. So we don't want to do anything that would change the length or diameter of the cap tube.

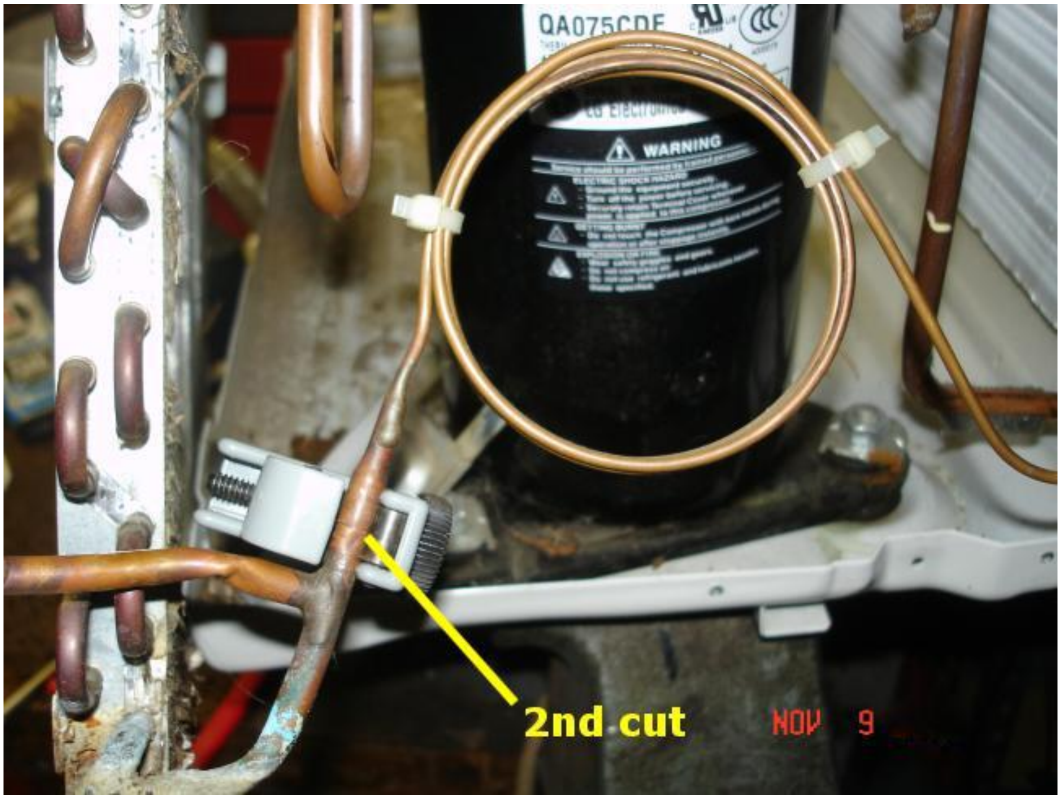
So when I choose where to make my cuts on the tubing, I will prioritize salvaging the cap tube over salvaging the evaporator & condenser parts. If I can salvage everything, better yet.

Here is a photo of the first cut to remove the cap tube. I had to pull the copper tube out away from the evaporator core a small amount to allow me to position and turn the little tube cutter. I left enough of the 1/4 inch tubing so that I will be able to re-braze the cap tube into the new circuit, and not have to change the length of the cap tube.



I have made a red mark on the photo to indicate another good place where the cut could have been made...

Here is the second cut to remove the cap tube. Space and choices were both very limited here.



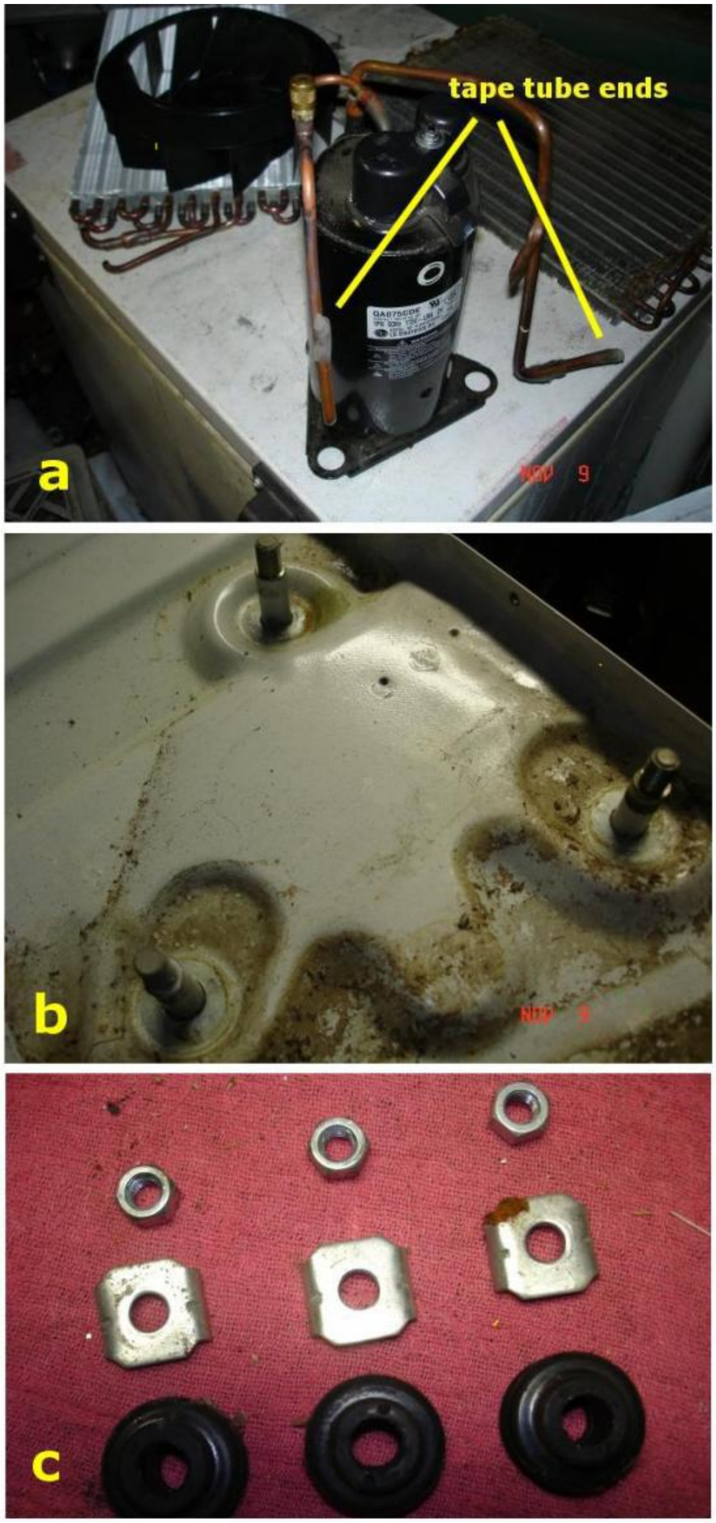
Not much more to say here, except work very carefully.

Please note that cap tube is **not** made from soft copper like the rest of the tubing is, and it will not bend easily like soft copper.

So here's our prize, the part we have been so careful to remove...

...probably a good idea to put the cap tube in a plastic bag to keep any dust & bugs out.

So after more cutting, here's what's left:



Pix - a shows the compressor, and the condenser core and the evaporator core.

Pix - b shows the compressor mounting area on the bottom pan. You may choose to use the bottom pan as is, or you may choose to create a new bottom pan from scratch, or you may choose to cut the compressor mounting section off of the old bottom pan and use it on the new one.

Pix - c shows the vibration mounts from the AC unit. There is actually a fair amount of engineering that went into these mounts, so best to save and re-use them no matter how you want to deal with the bottom pan on your new unit.

So we now have our unit fully dis-assembled and are ready to begin thinking about how we can re-assemble it into a vapor compression device that will do useful and efficient work for us.

Beginning Loop Testing...

Today I decided to hook up a pump to the ground loop that was previously put in.

I have several diferent pumps laying about, so I decided to start with the smallest, cheapest one to see what the performance was like.

The pump is actually sold as an aquarium pump. it draws 35 watts and has a magnetically-driven impellor. I've misplaced the specifications for the volume and head curves of the pump.

I made an adapter to connect the 1/2 inch MPT output of the pump to a 3/4 barbed connector and connected the pump to the input of the loop field. The pump went into the bottom of a barrel and the output from the loop field went into the barrel also.

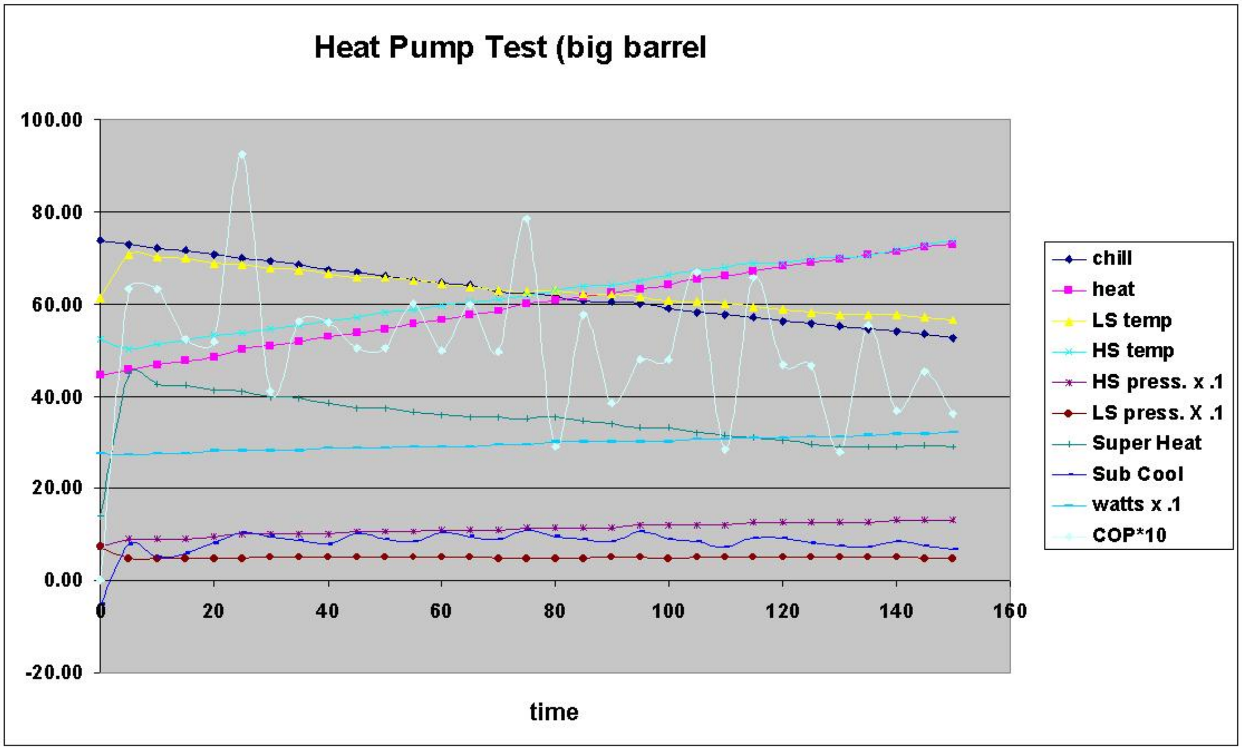
When I plugged the pump in, I wasn't really sure if it would even have enough power to circulate the water at all through the loop field. I was also very corious what the temperature of the loop field would be.

I tested regular tap water and it was stabilizing at 49F to 50F.

The loop flow from the aquarium pump was really pathetic, I measured the time it took to fill a gallon jug, and it took 3 minutes to fill it up.

After the water in the loop had flowed (slowly) for maybe 45 minutes I took another reading and it was a 51 degrees. I had expected it to be higher, but I'm more interested in what actually is.

The test I ran two summers ago yielded this graph:



... The black line, labeled "chill" was temperature if the barrel I was cooling... like the incoming water in the loop field. The light blue line, labeled "COP*10", that is bouncing all over the place like a drunken flea is the momentary, calculated COP. If I imagine a trend-line through the COP line (by thinking like a sober flea), it looks like it will be about COP = 4 when the incoming water temperature is about 50F. Not as good as I had hoped for, but good enough to keep on with the testing...

I noticed small bits of debris drifting in during the hour or so that I ran the pump. The procedure calls for a linear velocity of at least 2 feet per second to flush out debris. I haven't calculated the velocity of the water driveling through the pipe, but it was way, way below 2 FPS.

Next step, hook up the next larger pump and continue flushing debris & purging air.

I broke out my quarter horse sump pump that I bought recently for flushing my tankless water heater.

The hook-up was so much easier than it was for my aquarium pump, that I don't even know why I bothered with the little pump.

Once I shook all the air bubbles out of the pump it started working pretty good, with much better water flow than before.

I could see that air pockets were being purged by the better flow rate. I also noticed that the more air I purged, the better the flow rate.

I filled up a gallon jug with the outlet pipe from the loop field, and timed it with the second hand of my watch. It took almost exactly 30 seconds to fill the jug (much better than the three minutes from the aquarium pump).

Next task was to calculate the linear flow rate to see how that stacked up against the recommended minimum 2 linear feet per second (2 FPS) flow rate.

I measured the ID of the pipe to be .815 inch

From this I calculated the area of the pipe to be .5217 square inch.

Next I multiplied the area by 24 inches per second (2 FPS) to get 12.52 cubic inches per second.

Then multiplied by 60 seconds per minute to get 751.2 cubic inches per minute.

Then divided by 231 inches per gallon to get 3.25 gallons per minute.

But I measured my fill rate to be only 2 gallons per minute, so I'm getting close, but I'm still short, according to the recommendations in the procedure.

I fiddled around a bit with the tube and found that if I put my thumb briefly over the end of the tube and quickly let go, I could expel a bit more air, but that there was still more to expel.

So this is all telling me that the suggested 2 FPS minimum is really a reasonable and true number.

It also is telling me that I need a bigger pump for purging.

But through all of this, I am not seeing any more debris in the bottom of the barrel, so even the aquarium pump, as wimpy as it is, was enough to get those debris bits out.

The sump pump has been running for about four hours now. I made a level marker so I can tell if I lose any water.

I need to resuscitate my original homemade heat pump and hook the cold side up to the loop and hook the hot side up to a measured amount of water so that I can get some idea of the effectiveness of this thing.

The loop water temperature is measuring 51F. Outside the air temp is 36F.

Delta T is 15F.

I guess there's some satisfaction in that.

I have been experiencing a slow drop in the level of water that is being circulated in the loop.

I wasn't sure if it was because I was too casual in my measurements, or if I had a slow leak in the system that I had not caught.

A slow leak was certainly possible in the 720 feet of HDPE, which featured more than 112 hand-welded joints, done with homemade thrift store sourced components. I did test all the welds before burying the pipe, but accidents can happen.

So last night, I was very careful when I measured the water level, and I noted the exact time of the measurement. I also noticed that ever since I installed the quarter horse sump pump, a very thin stream of occasional bubbles had been coming from the loop output (where the output tube goes into the barrel, I put on some transparent tubing, and the end is beneath the surface of the water, making thin bubble streams easy to spot). This held out another explanation as to why the water level was slowly dropping... because air was being slowly purged from the system, in the form of a thin bubble stream.

If I had a more robust pump, The purging would most likely have been done in the first hour.

So this morning I went down to look at the water tank again and I saw no more evidence of the bubble stream, so it looks like the purging process is complete.

I also carefully checked the level of water in the barrel, and there was no perceivable change in level over a 15 hours period. If I don't see any change in level over the next few days, I'll call it a perfect loop.

I just went down to the cellar and measured the level of the water in the barrel where the sump pump has been churning away for the last four days. I am happy to report that there has been **no change** in the level of the water that is circulating through the loop field. I was expecting at least a tiny drop in level from evaporation, but I can't see any change whatsoever.

So the loop-field is holding perfectly, and all 112(plus) welded joints are functioning exactly as I had planned.

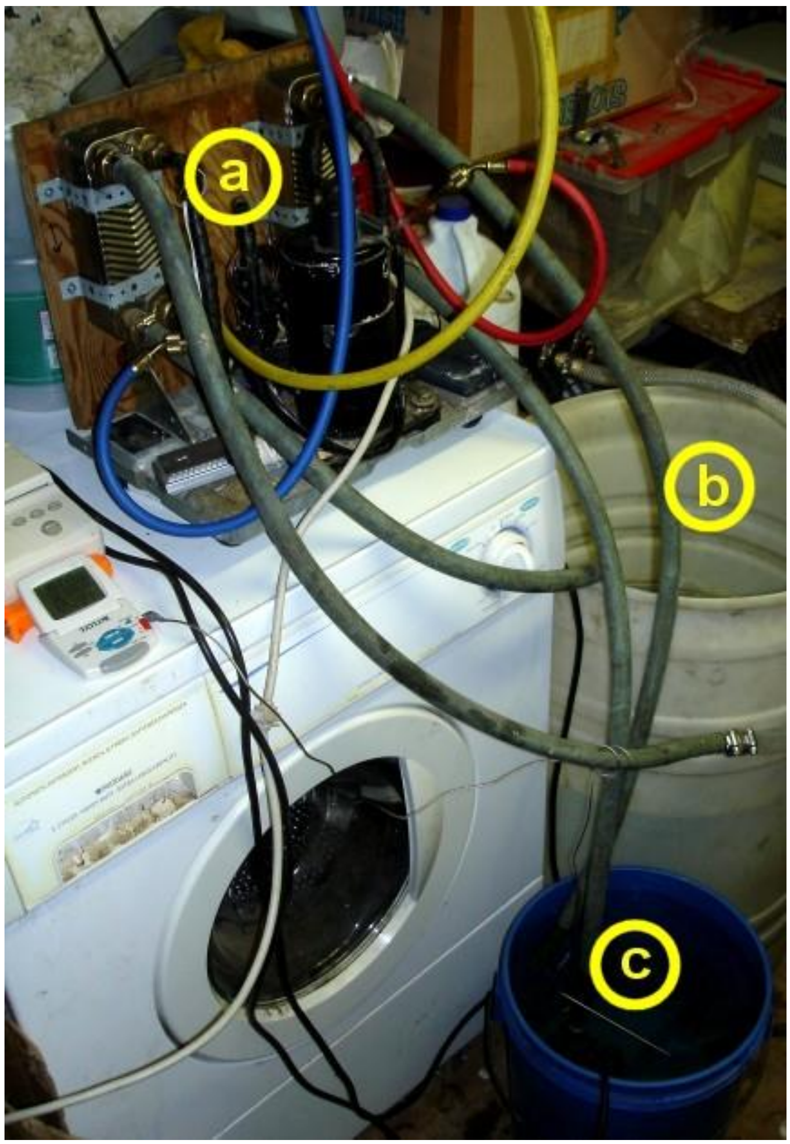
Looking back, it is good that I tested all joints, because I did find two joints that were leakers, and I was able to replace/repair them before I installed them in the boreholes.

So, while I did all of my research, and was very careful when I worked, and did test everything as I went along, it is extraordinarily gratifying that the whole loop field is working perfectly.

Ground Loop + Heat Pump Test #1

Yesterday I did a test of my homemade heat pump. This is the first test with the heat pump finally hooked up to the loop field.

Here's a photo of the setup.



"a" is the homemade heat pump that I built. I've learned a lot since then but I think I can learn more from this unit, before I build the next one.

Here is an older photo of the heat pump, showing better detail...

"b" is the white "source" barrel (so named because the ground loop is where the source of low grade heat is coming from). This is the barrel that has the water coming from the ground loop. I have a quarter-horse sump pump pushing water through aproximately 720 feet of high density polyethylene pipe buried in the back yard. The water then returns from the loop and enters the brazed plate heat exchanger on the left side (evaporator side) of the heat pump. After exiting the heat exchanger, the water flows back into the 'source' barrel, and the cycle begins again.

The photo below is a detail of the source barrel and the sump pump. I measured the sump pump and it was drawing around 250 watts of power, ok for initial testing, but way too much for normal operation.

"c" is the sink bucket (blue 5 gallon bucket)

The photo below is a detail of the 'sink' bucket (so named because this is where the high grade heat is going to). Here the water is pumped from the bucket into the brazed plate heat exchanger which is on the right side (evaporator side) of my heat pump. After exiting the heat exchanger, the water flows back into the bucket.

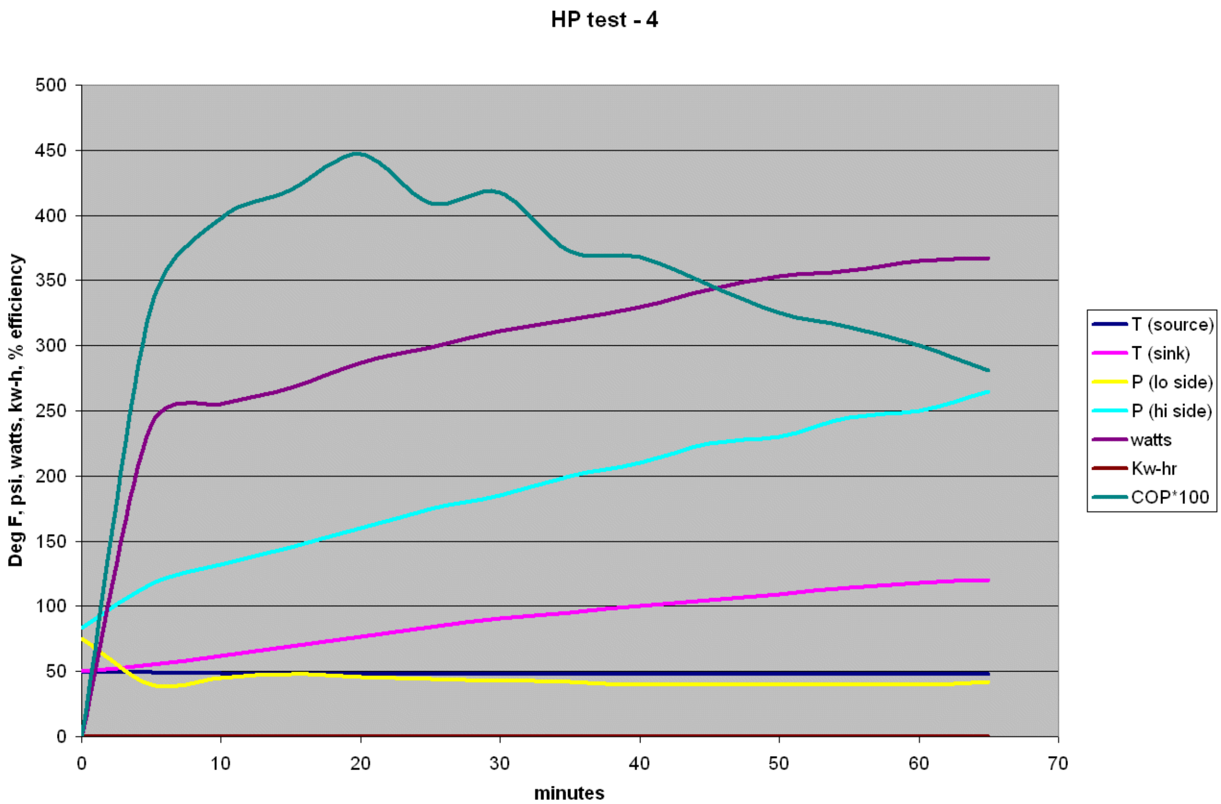
I measured the pump, (actually a heavy duty aquarium pump) and it was drawing around 25 watts of power.

The photo below, is a closeup of the point where the capillary tube enters the brazed plate, evaporator side (left side) heat exchanger. The frost gives me an indication that things are working. I should have positioned the cap tube at the top of the exchanger, so that gravity would be working for me. I will incorporate this improvement into the next unit.

Logging Improvements

- I have started using a digital clock (the one on the Kill-a-Watt) and the time is more reliable.
- I have insulated under the bottom of the blue bucket, so heat is not being lost through conduction into the basement floor.
- I've started logging the cumulative kw-h with the Kill-a-Watt, and using that in the COP calculations.
- I have started using a thermometer that responds in tenths of a degree to measure the loop water temp.

Below is the chart for this test, as in the prior tests, the energy used by the pumps is not being considered.



I've made the lines easier to read.

Due to the automatic scaling,the kw-h line is at the very bottom of the chart.

The COP*100 line looks pretty favorable (even pushing over 400%!), especially when the heat-sink temperatures are down below 100 degree range (when the "lift" isn't so high). This really speaks volumes about the advantage of radiant floor heating (huge radiating area, lower feed temperature), where feed temperatures are in the range of 85 to 95 degrees, compared to forced air (smaller radiating area, higher feed temperatures) where the feed temperatures are in the range of 120 degrees.

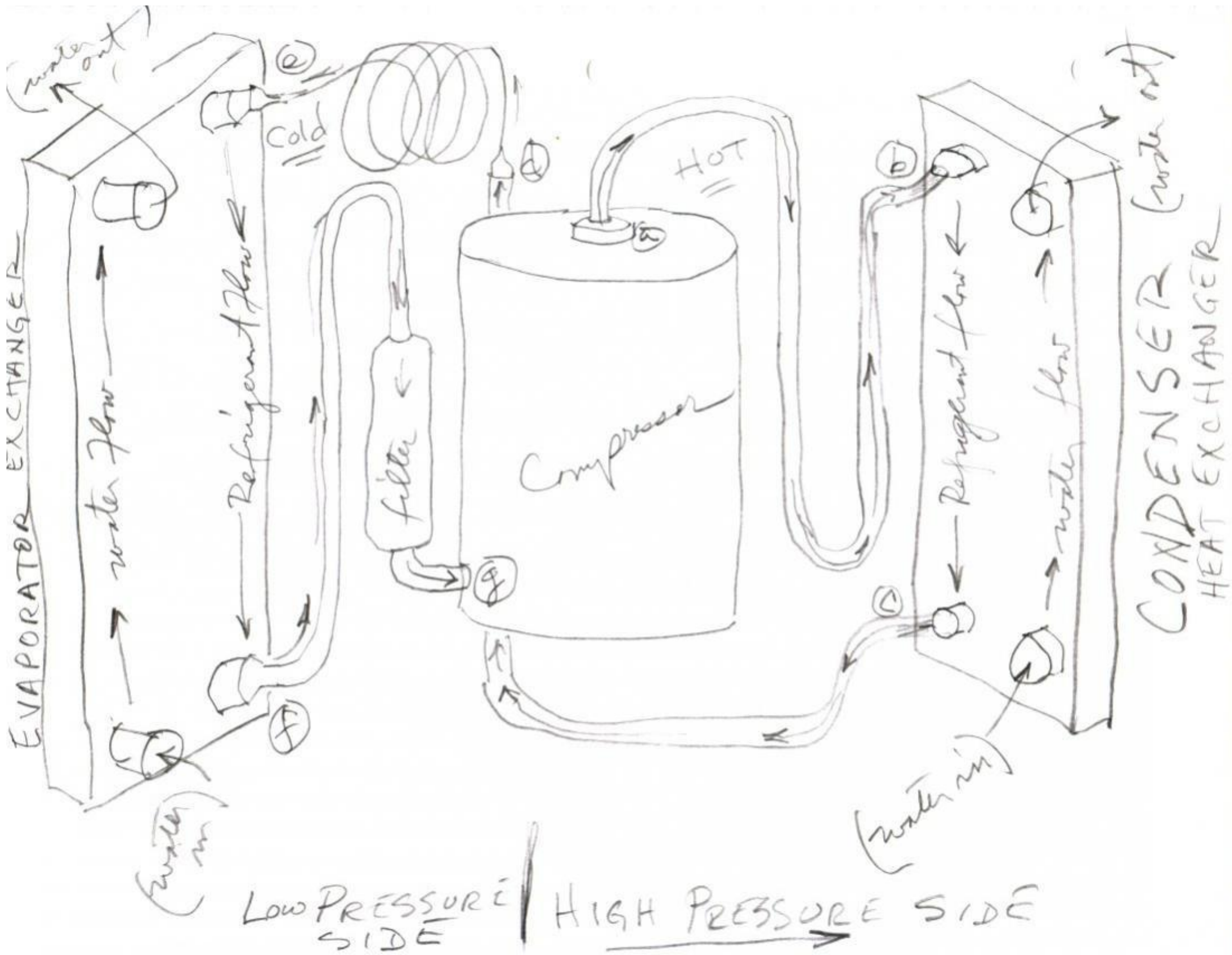
Below is the logged data for this test.

	A	B	C	D	E	F	G	H
1	minutes	T (source)	T (sink)	P (lo side)	P (hi side)	watts	Kw-hr	COP*100
2	0	50.2	50	75	83	0	0	#DIV/0!
3	5	49.3	55	40	117	240	0.02	331
4	10	48.5	62	45	132	255	0.04	397
5	15	48.2	69	48	145	268	0.06	419
6	20	47.8	77	46	160	287	0.08	447
7	25	47.6	84	44	175	299	0.11	409
8	30	47.6	91	43	185	311	0.13	418
9	35	47.6	95	42	200	320	0.16	372
10	40	47.6	100	40	210	330	0.18	368
11	45	47.6	105	40	225	343	0.21	347
12	50	47.8	109	40	230	353	0.24	326
13	55	48	114	40	245	358	0.27	314
14	60	48.2	118	40	250	365	0.3	300
15	65	48.2	120	42	265	367	0.33	281

Curiously, the temperature of the loop field (AKA: 'T(source)') starts to climb a bit toward the end of the test. I think this is due to the heat being produced by the quarter-horse sump pump.

So next on the agenda is looking for a much lower wattage pump that can still provide sufficient circulation through the loop field.

Here You can see a detailed scheme of the Heat Pump :



I didn't draw the wires going to the compressor for clarity...

a.) This is where the refrigerant leaves the compressor, and so it's where the circuit starts. The compressor squeezes the vapor a lot and when a gas is squeezed (AKA: compressed) it gets hot. So if you touched the tube leaving the compressor, it will be hot to the touch. It might be very hot, so be prepared to pull your finger away quickly.

b.) The refrigerant then flows through an up and then down path into the heat exchanger. It's no accident that the tubing goes through this long path... the compressor vibrates when it is running, and having a long path spreads the repeated stress out over a longer distance.

c.) This is where the refrigerant leaves the heat exchanger. It is best to have the refrigerant enter at the top and exit at the bottom, so that gravity will act in your favor. When the refrigerant flows through the exchanger, it is cooled by the water that is flowing in the **opposite direction** (very important for efficiency). A lot of the heat that the refrigerant had gained when it was compressed, has been picked up by the water. The hot water can be used for something useful, like heating your home in Alaska. In the process of giving up its heat, the hot vapor begins to turn to liquid refrigerant(AKA: it condenses). That is why this heat exchanger is referred to as the condenser.

d.) I hope it is clear in the drawing that the tube from c-to-d is passing behind the compressor, and is not going into the compressor. The point "d" is where the refrigerant tube is brazed to the very small diameter tube (AKA: capillary tube, or cap tube). The tiny tube going from d-to-e is the cap tube, and its small diameter, along with its length acts to slow and regulate the flow of the refrigerant in the system. Sometime the cap tube is refered to as a 'metering device'. So pressure builds up between the compressor and the cap tube. All the tubing from a-to-e is referred to as the high pressure side (AKA: high side).

e.) This is the point where the cap tube is brazed to some larger copper tube. When the high-pressure refrigerant leaves the cap tube, it sprays out and instantly goes into a vapor state (AKA: evaporates). When it evaporates, it gets cold, very cold. Just imagine a hot day and spraying water on your face... same thing.

This is also the place where the refrigerant (very cold refrigerant) enters the heat exchanger. Again, it is a very good idea to have the refrigerant entering from the top and exiting from the bottom, so that gravity is our friend. While the cold refrigerant flows through the heat exchanger, it is taking heat from the water that is flowing in the **opposite direction** (very important for efficiency).

So the water that flows through this heat exchanger (AKA: the evaporator) will flow next to some water. The water will give up some of its heat to the refrigerant. And the refrigerant will carry this heat on through the cycle.

This is where we run our ground-loop water. So even though the water is pretty chilly, it's about 50 degrees here in my loop, the refrigerant is so much colder, that it take the heat from the water...

f.) This is where the refrigerant exits the heat exchanger. The refrigerant will carry the heat that it picked up, with it on it's way to the compressor. Again, there is a loop, in fact, there should be another loop that I left out for clarity. But you need to have them there for stress relief. As the refrigerant passes from f-to-g, it passes through a filter that serves to hold excess refrigerant, and also to filter out any unwanted bits. There is also a dessicant that will trap water that may have been in the circuit. Water and refrigerant are not a good mix.

g.) This is where the refrigerant re-enters the compressor. the refrigerant has been cooled by rapid evaporation, then warmed somewhat by water in the heat exchanger, but it is cool enough to keep the compressor running cooler... but it does pick up some heat from the compressor.

So there you have it.

Ground Source Shop Warmer now working...

I have re-configured my heat pump to work as a Ground Source Shop Warmer. It is now running, warming my uninsulated basement shop.

I borrowed an automobile radiator from Bruce-the-Pirate and hooked up the output water loop (and circulation pump) to it. The setup, crude as it is, is working.

I'm using a box fan to blow air through the radiator.

The ground loop temperature pulled down to about 46 degrees... the radiator-loop temperature stabilized at around 73 degrees and after running it for several hours, the temperature in the unheated basement stabilized at 60 F... not too bad for a shop.

I haven't calculated efficiency for the setup (my estimate is COP =2), but it is clearly better than the 220 V, 2400 watt resistance heater I was previously using.

This is the end of the DIY Geothermal Heat Pump Journal. I am planning to build another pump very soon, I will come with updates when I finish testing the new design.