Son of Fermentation Chiller

or, "Better Late than Never..."

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The Next Generation

I first published plans for the original Fermentation Chiller in May of 1995. In the ensuing time I have been contacted by many people who have built the Chiller and offered good-quality feedback. I also re-thought several of the design features of the Chiller based on my own experiences. I figured it was time for "Son of Fermentation Chiller", a new design document with these improvements implemented. Highlights include:

- Enlarged Fermentation Chamber will accommodate a 7-gallon bucket, with airlock, handle, spigot, and the works.
- Wider design allows both the Intake Chamber and the Ice Chamber to hold ice, eliminating the need to stack the jugs (which often causes ruptured jugs when the ice melts). You could still stack the ice, allowing use of four jugs for initial chilling and/or low-temperature operation (for fermenting lagers). An idea is presented to prevent rupturing when stacking.
- Shorter overall height makes loading/unloading ice easier.
- Change in design of the fit of the Top and Front panels seals much better.
- Reinforced dowel-holes provide lasting tight fit of Top and Front panels.
- "Weep" holes to drain condensation.

If you've already built a Chiller, you can incorporate many of these improvements into your existing unit.

What Is the Fermentation Chiller?

The Fermentation Chiller is an insulated box which uses ice, a thermostat, and a small fan to accurately regulate the temperature of a fermenter. Maintaining proper fermentation temperature is a crucial part of producing clean, high-quality homebrews. While simpler insulated boxes and other simple temperature-management techniques often work reasonably well, they can't *regulate* the temperature; they can only cool to "some point" below ambient, which changes as the ice melts.

I have routinely used the Chiller to obtain up to a 30-degree Fahrenheit (17C) drop in temperature relative to ambient. Thus, I have been able to produce a Steam beer at 60F in my garage in summertime, which often stays for hours at 95F and is almost always above 85F. If you have a place in your living area to use the Chiller, you should be able to ferment lagers effectively at 50F with typical "room temperatures".

The Chiller can only *cool* (it's "powered" by ice); it relies on a higher outside ambient temperature to balance the cold air inside, thereby maintaining a precise temperature. **I do not recommend that you attempt to attach any heating device nor that you use household current (120 VAC) as this could be a potential fire hazard.** Using the Chiller indoors during the winter will allow adequate operation even at lager temperatures.

What Kind of Performance Can I Expect?

The "power" for the Chiller's cooling capacity comes from gallon jugs of ice. With a nominally-15F differential between your wort and the outside world, you'll need to change the ice about every two days. Higher differentials will of course mean more frequent ice changes. Having four jugs of ice available allows you to "rotate" them through the Chiller -- two in the Chiller and two in the freezer. You'll notice that the fan doesn't cycle very much once the wort is at temperature; it really requires very little work to "maintain" the temperature. And if your summertime tap water temperature is too warm for your wort chiller to yield cool wort, a few hours in the Chiller at full-on will quickly bring the wort several degrees lower for pitching.

How Does It Work?

The key to the Chiller's control is the thermostat. It only circulates cold air from the ice when the temperature begins to rise. The arrangement of the panels inside the Chiller "traps" the cold air behind the Fan panel; the Baffle directs the air flow so that the warmer air at the top of the Fermentation Chamber flows down and then back up across the ice before returning to the top of the Fermentation Chamber. By doling out measured doses of cold air, a precise temperature can be closely maintained in the Fermentation Chamber. And by "corralling" the cold air behind the Fan panel, maximum service can be obtained from the ice.

How Much Does It Eat?

The unit operates off safe low-voltage DC current from an AC adapter. The low-power fan (less than two watts) and low average duty cycle make it a very efficient unit to operate. You'll probably use more energy freezing the jugs in the freezer than you will running the Chiller!

How Much Does It Cost To Build?

Expect to spend $60 - $70 if you obtain all the material brand-new. You can do much better than this if you shop carefully and obtain what you can from surplus houses and dealers. The extruded polystyrene is highly recommended, although some Chillers have been successfully built with white styrofoam "beadboard". Beadboard lacks the structural strength of the extruded polystyrene but is considerably less expensive and easy to find. With care in construction and use, it should provide good service.

$70!!?? Why Shouldn't I Just Buy A Used Fridge?

Good question! But even if you got a used fridge for free, you'll probably still have to spend $40 or more on a "brewer's" thermostat controller (for higher operating temperatures). Refrigerators can take up a lot of room, and older refrigerators can be quite inefficient, using a lot of electricity. The Chiller takes up less than a two-foot by three-foot area, and can easily be moved by one person. It can be stored in an attic or shed when not being used (try *that* with a refrigerator!), or located in a closet or pantry when it is being used. It uses very little electricity, costing almost nothing to run (although some energy is consumed when freezing the jugs in your freezer).

How Hard Is It To Build?

While some very basic woodworking-type construction skills are required, the construction is not difficult and you probably have (or can easily borrow) all the tools you'll need.

Sources for Parts & Supplies

The fan and AC adapter are available from a number of sources, including Radio Shack (convenient but pricey). Their 273-247 fan and a 273-1652 12-volt AC adapter will work fine but will set you back almost $30. Two other sources of inexpensive parts are Jameco (800-831-4242) and All Electronics (800-826-5432). Look for a 3-inch 12-volt DC fan and a 12-volt DC adapter capable of supplying enough juice to run the fan (200 mA is usually enough). Jameco often closes out suitable AC adapters for as little as $2, and fans can be had for $7 or $8. I believe these two suppliers have no minimum order but do charge shipping and/or handling on small orders.

Use construction adhesive such as Liquid Nails for Projects. You might actually save money buying a cheap caulk gun and the gun tube package, over buying the smaller "toothpaste tube" style package. See the text for other information on various parts.

About The Foamboard

This seems to be the most difficult item for folks to locate, and they're often surprised at how expensive it is. That much is true. Most "Home" stores don't carry the 2-inch thick extruded polystyrene material. The white "beadboard" can usually be easily found but as mentioned above, its structural strength and low density will require you to be very careful handling it. To find the recommended extruded polystyrene brand-new, try an insulation supply dealer, or ask an insulation contractor if they know where to get some. Expect to pay $20 - $25 or more for a new four-by-eight sheet.

Two-inch polystyrene insulation is often used at industrial and commercial construction sites. You can visit a construction site and ask the crew for any scraps. They may be in a position to offer you complete sheets or large scraps if they have extra. But please, *don't just "help* *yourself"!!* You might be surprised at how cooperative people can be if you're honest and ask. And offering a couple of homebrews in return can be an effective bartering technique.

Gluing two sheets of material together is also a workable approach. Three-quarter-inch and one-inch four-by-eight stock is often sold at the "Home" stores, resulting in a 1-1/2" or 2" panel thickness. If you make a 1-1/2" panel, make the Sides one inch shorter (top to bottom), to account for the thinner sheet stock. The inside dimensions of the Chiller will then remain the same (actually the Fermentation Chamber will be a bit larger, but who's counting?). The downsides to the 1-1/2" material include lower insulation R-value for the 1-1/2" design (about 25% less), meaning more frequent ice changes, and the extra work & glue involved in laminating the sheets together. You don't have to completely coat one sheet with glue; running single thin beads a few inches apart, along the length of the panel, should do the trick. Spread the glue fairly thin and carefully join the two sheets. Weight the sandwich evenly on a flat surface (floor) until the glue has completely dried before cutting out the pieces.

If you have access to lots of "scrap" plywood you might consider making a sandwich of two 1/4" or 1/2" plywood panels with 1" foam between. This will result in a 1-1/2" or a 2" sheet thickness. The wood's R-value is not as good as the insulation's but should still provide adequate performance. Cutting and joining these panels will require extra thought and effort. Some sort of protection of the wood from spills and condensation from the ice is required as well (polyurethane finish or whatever). You can also substitute plywood of almost any thickness for the Fan and Baffle panels, even if you use foamboard for the "shell", since the insulation value of these interior panels is not as critical as the exterior panels.

Monitoring the Wort Temperature

Keeping tabs on the wort temperature is possible by mounting a thermometer onto the outside of the Chiller. I use an inexpensive digital indoor/outdoor thermometer, with the "outdoor" probe run through a small hole in the Side and mounted near the thermostat. Set the thermometer's selector switch to "outside" to display the probe's temperature. Radio Shack sells one that often goes on sale for $11.

You can also use one of those little dial thermometers with the 5" probe. Simply push the probe through the Side so that it sticks through near the Fan board about halfway up the Fan board.

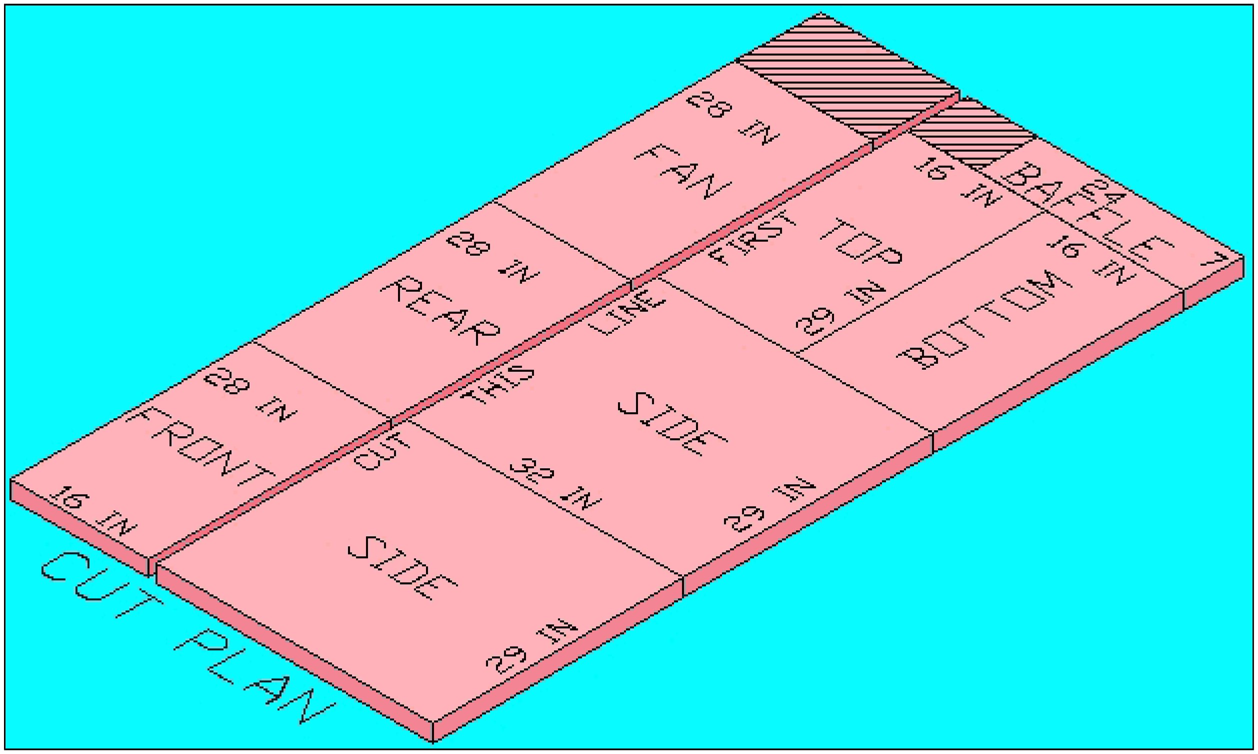
I recommend adding one of those liquid crystal thermometer strips to your fermenter too. Remember that your thermometer and thermostat are measuring *air* temperature. Once equilibrium is reached the air and wort temperatures will be about equal, but adding the thermometer strip will allow you to monitor both the air and the wort. Fermentation can generate a lot of heat and oftentimes the wort temperature will be higher than the air temperature.

Construction

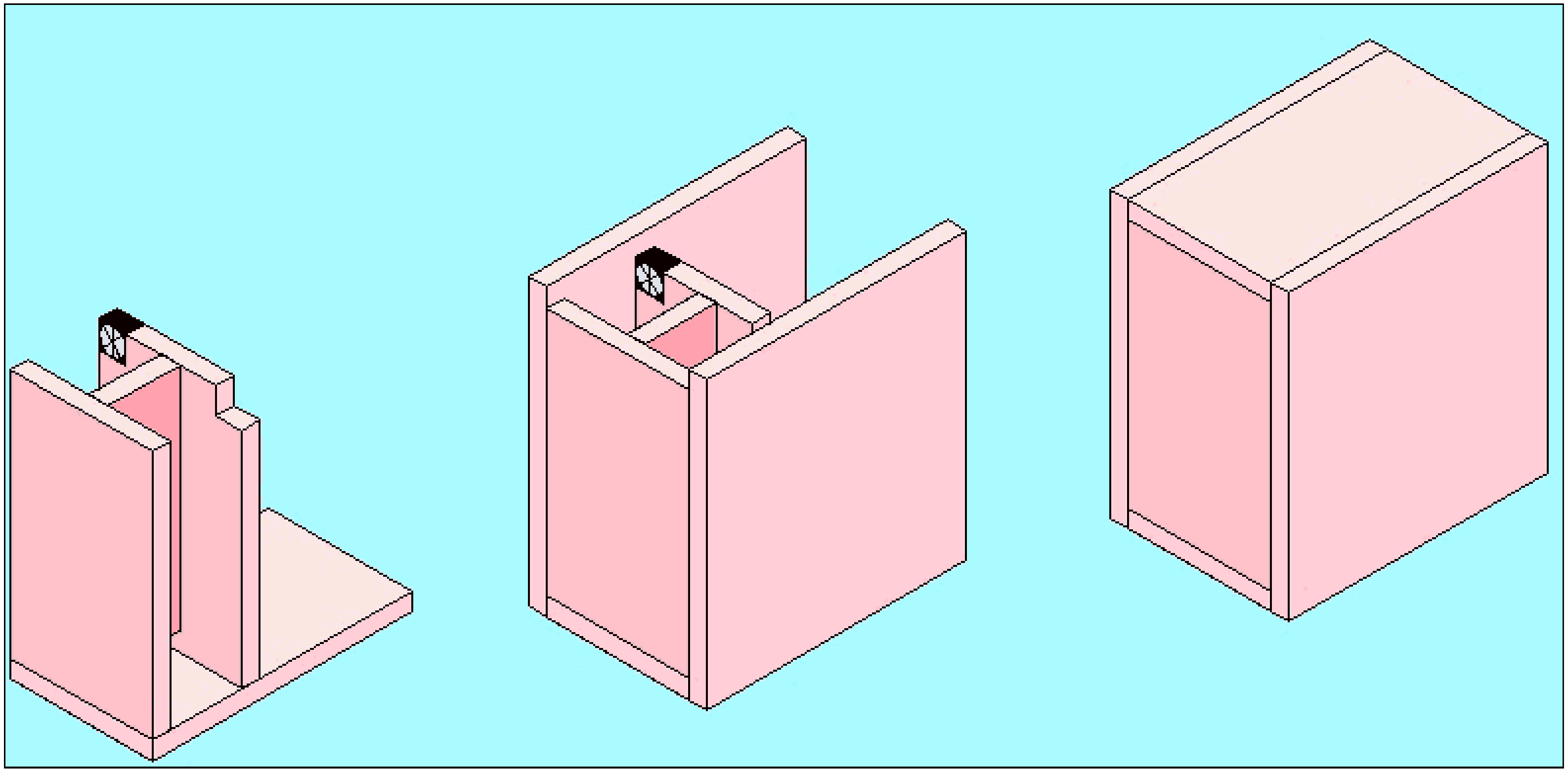
I purposely included a very few illustrations for the construction because...I'm too damned *lazy*!! Look how long it took to get this document put together as it is!! Seriously, I think you can get the picture by looking at the illustrations that I did include and carefully reading the text.

The answer to your question is probably in here somewhere.

Cut out all the pieces using the layout or "cut plan" shown. Draw the lines directly onto the foamboard with a pen (a "Sharpie" works nicely). Remember to make any necessary changes if you're using other than two-inch material. I've found an electric saber saw used freehand (slowly and carefully) works best. The foamboard is too soft for a circular saw to offer any benefit in cutting a straight line; in fact, you're more likely to wobble since it's a heavier tool. Trying to clamp a straightedge to the soft foamboard is futile as well. Don't worry if the cuts aren't perfectly straight, or if the pieces are not exactly the right size -- the construction adhesive will fill a lot of gaps for you!! Do try to make a square cut though, so the pieces butt together squarely. Keep the pieces straight by marking them so you don't mix them up (the Top and Bottom are only slightly shorter than the Front, Fan, and Rear panels, so it's easy to get confused.



First, cut two 3"-square notches in the two corners at one end of the Fan panel. See the left-hand figure in the illustration. One notch is the "intake port" and the other notch will hold the fan. Glue your 3" fan in either corner but make sure you don't get glue on the fan blades -- the fan will be unbalanced and will wear the bearings quickly before burning up in a horrible blaze of glory (and it makes a hell of a racket in the process). Orient the fan in either direction (see *"Breathe In, Breathe Out"* below for info on airflow direction). Glue the edge of the Baffle to the Fan panel along the Fan panel's centerline, flush with the notched (top) edge of the Fan panel. Secure the Baffle in place with a few strips of masking tape to keep the Baffle from sliding around while the glue is still wet.



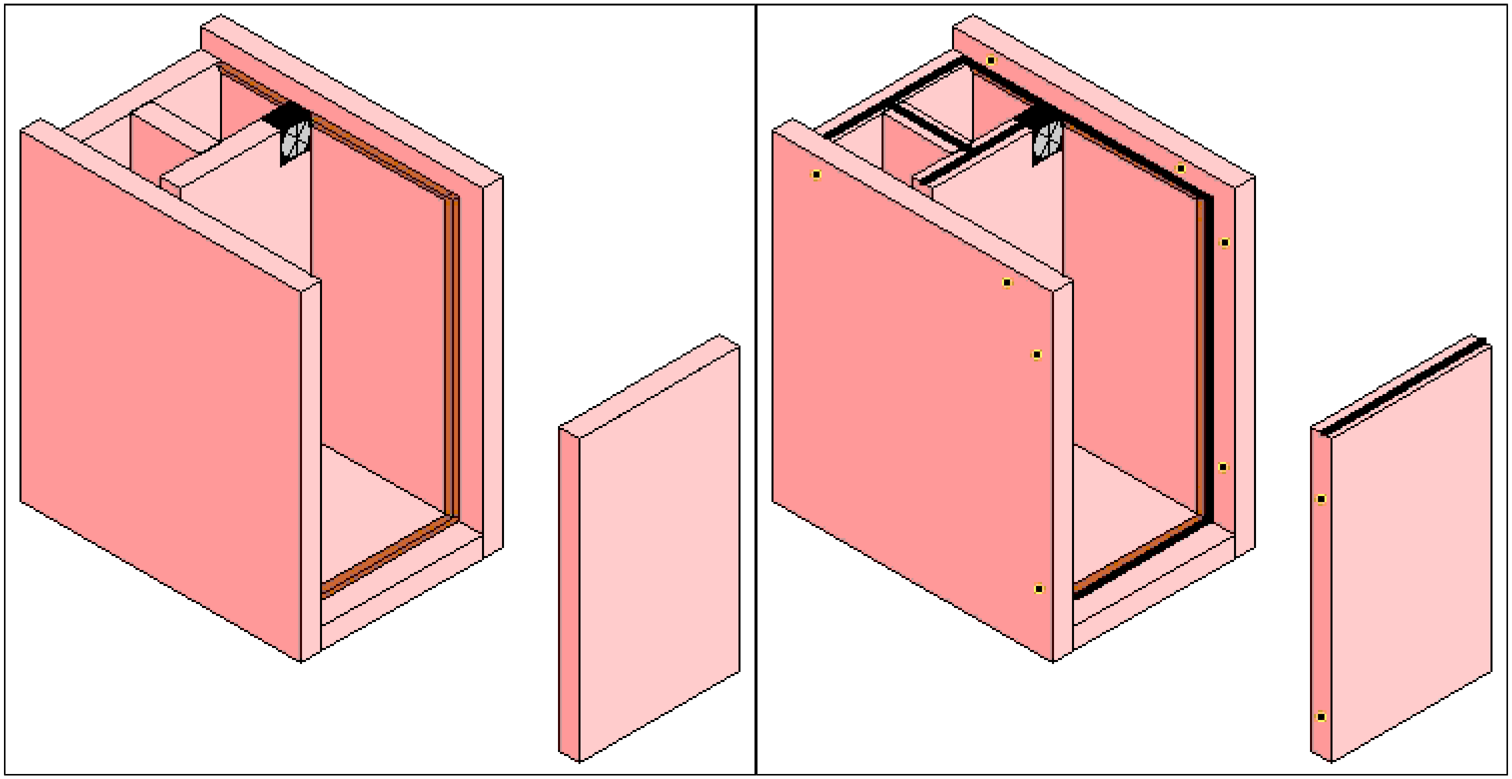
Glue the bottom edge of the Rear panel to one end of the Bottom, on the Bottom's "top" surface. Put glue on the non-notched edge of the Fan panel and the exposed long edge of the Baffle, and attach it to the Bottom so the Baffle is glued to the Rear (see center figure in illustration). Square up all the panels and edges so that everything is straight and square. Be sure that the Ice chambers are of equal size (7" by 7") so the jugs will fit.

Put glue on the side and rear edges of the Bottom panel, the side edges of the Rear panel, and the side edges of the Fan panel. Attach the Sides flush with the floor and again square things up. You can temporarily fit the Front and Top panels in place *without glue* to help keep everything straight while the glue dries overnight (see right-hand figure in illustration). A bit of masking tape can hold things in place while the glue is setting up. Once all the glue is dry, remove any masking tape from the Baffle and elsewhere.

Run a fillet of glue or caulk along all interior corners to "seal" the Chiller. Some areas will be a tight reach but do the best you can. The Fan and Baffle panels do not really need sealing since they are completely interior. A little air leakage won't hurt much, but any obvious gaps should be plugged. Seal the inside corners formed between the Rear and the Bottom, the Sides and the Bottom, and the Rear and the Sides.

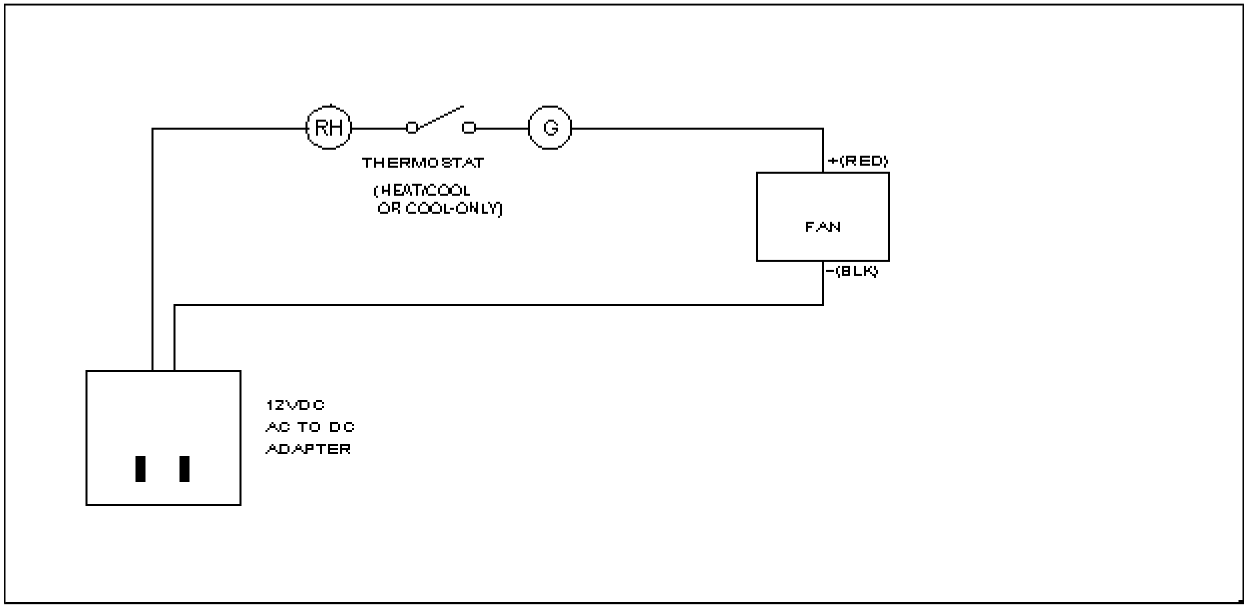
Mount the thermostat to the Fan panel with glue or Velcro (if using a liquid-metal unit). Almost any place is fine but put it where you can get at it when a carboy is in place. I put mine a few inches from the top off to one side. Poke a small hole near the bottom of either Side for the AC adapter wire to pass through, near the Fan panel. Choose the Side that will be most convenient as far as the wire exit goes. Cut off any plug on the low-voltage side of the adapter and pass the wire through the hole. Wire to the thermostat (see "About Thermostats" section below).

Cut and attach 1/2" square or quarter-round wood molding to the inside of the Sides around the perimeter of the Top and Front areas (see illustration). Cut and attach 1/2" wide by 1/4" thick open-cell weather stripping across the top edges of the Fan and Baffle panels, to the top face of the molding along the top edge of the Side, and to the front face of the molding along the front edge of the Side. Also add a strip of weather stripping to the top edge of the Front panel.



About Thermostats

You have a few options for the thermostat. The simplest thing to do is to use a heat/cool thermostat designed for the home. These retail new for around $15 or so. Connection is made to the "RH" and the "G" terminals, which are the "switching" terminals of the cooling function of the thermostat.



Note: Do NOT use "programmable" or "digital" thermostats, as they require the "normal" 24 VAC power supply to operate, rather than the 12 VDC we're using. Stick to the simple, mechanical units described here.

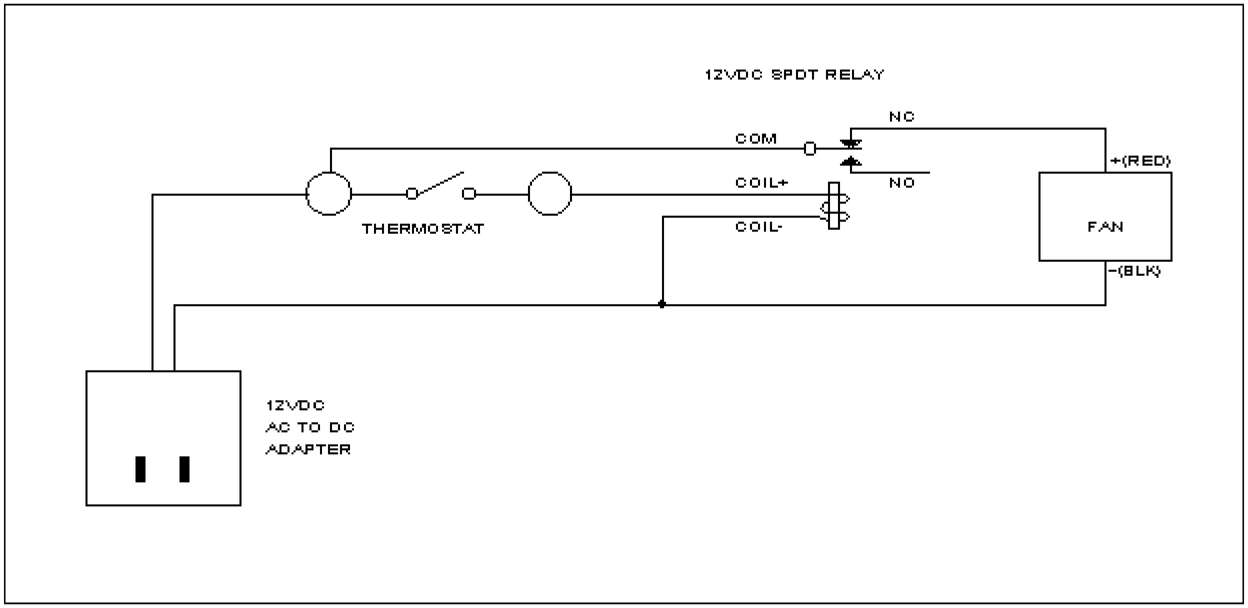
There are two basic kinds of home thermostat. One is the "bimetal switch" type, which uses a coil made of two metal strips bonded together, which tightens or loosens with changing temperature. A switch contact attached to the coil makes and breaks the electrical connection formed with a second contact fixed to the thermostat body as this coil moves. The other kind is the "liquid metal" kind, which also uses a bimetal coil, but the switching mechanism is a mercury switch mounted on the coil. The mercury switch is a bulb of glass with a ball of mercury inside, which electrically connects two contact posts when the bulb is tipped to one side. As the coil tightens and loosens with temperature, the bulb is tipped "closed" or "open".

Either of these types will work fine, although the liquid-metal variety requires leveling, since the switch's trip position depends on gravity. If you use this kind, I would suggest mounting the thermostat with Velcro so that it can be easily leveled if the Chiller is moved. The liquid-metal thermostat has an added bonus feature in that it can be intentionally mounted at an angle to change the temperature range. If you need a temperature setting that's below the lowest setting provided by the thermostat, you can rotate it when mounting it, so that the coil holding the mercury bulb must turn farther (in the "cold" direction) before the switch activates. You'll have to manually recalibrate the settings if you do this.

Please note that most thermostats are designed for 24 VAC operation. This however does not preclude them from operating at a *lower* voltage, nor with DC instead of AC. Thus, don't be confused by the thermostat's "24 VAC" rating and the Chiller's "12 VDC" power supply.

The bimetal and liquid metal thermostats are basically just mechanical switches and will work just fine with 12 VDC.

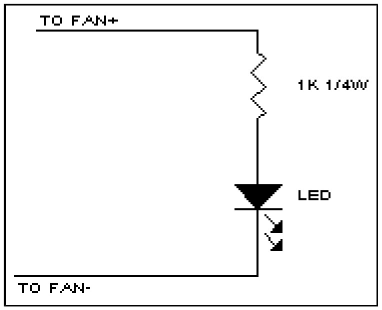
Another approach which will be less expensive (under $10) but requires some soldering is to use a heat-only thermostat to operate a relay. This effectively converts the thermostat to a "cool-only". Radio Shack's 275-241 relay is very tiny, and will mount inside most cheapie thermostat housings with a little hot glue or two-sided foam tape. Wire the relay in series with the thermostat so that its coil is energized when the thermostat turns on. Use the "COM" (common) and the "NC" (normally-closed) relay terminals to switch the fan. Now, when the thermostat turns "on", meaning it's "too cold" (this is a heating thermostat, right?), the NC relay contacts will turn "off". The fan stops and the Chiller eventually warms up. The thermostat, sensing that it's now "warm enough", turns the relay "off", which closes the NC relay contacts and turns on the fan.



Adding a "Fan Running" Indicator

Some folks might like to be able to tell from the outside of the Chiller when the fan is "on". This is a simple matter of adding a light bulb or an LED as an indicator. If you use a regular incandescent bulb, be sure (a) that it's rated for 12-volt DC operation (a bulb for an automobile application would fit the bill) and (b) that the AC adapter you use can supply enough current (mA) to drive both the fan and the bulb.

An LED will work well and only requires a small amount of additional current (10 mA for the LED versus up to 100 mA for some bulbs). An LED must *never* be wired directly across the fan -- a series resistor of about 1K ohms must be added. Furthermore, LED's are "polarized" meaning they will only light if the current flowing through is in the "right" direction. Check the packaging that the LED came with. The lead marked "anode" should be wired to the "+" fan terminal through the resistor. The anode lead is often longer than the other to identify it.



Fan-Running Indicator

Tip on Operation

Unless you're able to get your wort to fermentation temperature before you place it in the Chiller, you can speed the initial chilling by setting the thermostat to the "ON" position instead of the "AUTO". If you're using a thermostat that does not have such a control, simply set the thermostat to its lowest temperature setting. This will cause the fan to run continuously, so watch the temperature of the wort. You'll also go through a batch of ice quickly. Once you've reached your target temperature, set the desired temperature and switch the thermostat to "AUTO". You may have to replace the ice at this point too.

Don't Move A Full Chiller!

Do not attempt to move a Chiller with a carboy or bucket in it!! Regardless of whether you're strong enough to lift the weight, neither the foamboard nor the glue joints can handle the load. Remove the brew before moving the Chiller. You can probably leave the ice in place without any trouble.

Better Sealing of Top and Front

A significant enhancement to the design involves using wood molding to provide a "lip" for the Top and Front panels to seal against, rather than relying on a seal against the side of the weather stripping as was done in the first design. This molding is inexpensive and is easily cut and glued into place. Using the molding and the grommets (see next section), an excellent and long-lasting seal can be achieved.

Put a Lid on It

I've added a refinement to the dowel approach to holding the Top and Front panels in place during Chiller operation. A problem I encountered from continuous use of the Chiller was that the holes for the dowels eventually "wore out" and loosened, so that the panels no longer fit tightly. Cold-air leaks resulted and ice changes became more frequent. To fix this, I added brass grommets (the kind sold for repairing tarps) to the holes, to protect them from wear. They come in a convenient package of 24 (for about $2; shop around!), which is exactly how many you'll need.

I used 3/8" grommets and 5/16" dowels. Discard the flat washer-like parts and use the "top-hat" pieces of the grommets. Make two 3/8" holes in each Side about 1" from the top (3/4" if using 1-1/2" panel stock) and a few inches away from the Front and Rear panels. See molding/weatherstripping illustration for approximate locations. Make two more holes in each side about 1" from the Front panel a few inches away from the Top and Bottom panels. If you use a powered drill, be careful since it's easy to ream the holes oversized; you can use a smaller bit and ream the hole later with a length of dowel or by pushing a 3/8" drill bit though by hand. I ran the drill bit through by hand without a drill to ensure a correctly-sized hole. I also took a 1" blade-style drill bit and carved a shallow "countersink" on both ends of the hole for the "brim" of the grommets to sit in, so the grommet is actually below the surface of the Side. This keeps the grommets on the Side and the Top or Front from rubbing together as the panels are placed or removed.

Apply a liberal amount of Liquid Nails to the outside of the extruded part of the grommet, as well as around the rim, then insert into both "ends" of the hole in the Side. Repeat for all 16 holes on the outside and inside surfaces of the Sides. Don't make hole in the Top or Front just yet. Allow the glue to completely set up before proceeding with the matching holes in the Front and Top panels.

Place the Front and Top panels into position. Mark the orientation of the Top panel so that it goes on the exact same way every time. Now, press down firmly on the Top, so that a good tight seal is formed against the weather stripping an molding, and insert the dowels through the grommeted holes in the Side one at a time, pressing on the edge of the Top panel to mark the correct hole location in the edge of the panel. Now, drill out a 1-1/2" deep hole at the mark, by hand using the drill bit, and countersink it as described above. Again, do this one hole at a time. After all four holes are created on each panel, add grommets to them and again allow the glue to set up before use. The grommets will protect the foam panels from wear and greatly prolong the life of the Chiller.

I also rounded the ends of the dowels so that they don't catch on the grommets as they are inserted into the holes.

Some people don't use the dowels at all, opting to place a heavy book or other item on the Top, and simply friction-fitting the Front into place. This works OK, although the seal of the Front panel will not be as effective.

Blowoff Tubing

Some brewers like to use a blowoff tube instead of an airlock. Several Chiller builders have written to me saying that they've bored a hole in the side, through which they pass the tubing to a bucket outside the Chiller. Considering that you'll want to remove and replace the tubing with each batch, I would suggest adding a "bushing" or to the hole, such as a piece of PVC or copper pipe, to protect the foamboard from becoming worn out from repeatedly inserting and removing the tubing.

Draining Condensation

Here in the desert, condensation is not too big of a problem, but folks in the Southeast who've used the Chiller in summer report significant condensation on the ice jugs. To add "weep" or drain holes, simply push a 2-1/2" or longer screw, nail, or drill bit through the Rear panel, at the very bottom of the panel, so the hole is even with the "floor" or the Ice chambers.

Because you'll have condensation, and also since you may have small leaks from less-than-perfect sealing during construction, place the Chiller on a surface which will not be damaged by any draining water. You could add some tubing to the weep holes to direct any drainage into a container, but I still suggest placing the unit on a towel or a tarp. Evaporation will help remove any water as it drains.

Breathe In, Breathe Out

A question that's been asked a few times is, "Which way should the fan blow -- into the Ice chamber or into the Fermentation Chiller?" Overall airflow velocity is the same either way, but the "quality" of the airflow is different. When air is blown out of a fan, it is turbulent, which is good from a heat-transfer standpoint. The air tumbles around, exposing more cold air to the fermenter. The air on the intake side flows in a somewhat smooth fashion, and less air will contact what it flows across than if it were turbulent. Whether the turbulent air should flow across the ice or the fermenter is open for debate. In either case, the airflow is likely to pick up turbulence as it passes through the Intake opening, so the point is probably moot. I haven't tried it both ways; I'm not convinced that a noticeable difference would result, so feel free to experiment. For what it's worth, my fan blows into the Fermentation Chamber.

Adding More Ice

For initial chilling of freshly-brewed wort to pitching temperature, or for lager fermentation, you might want to experiment with adding extra ice. One Chiller user suggested running a 1/4" dowel completely through the middle of the Ice chambers and the Baffle, from one Side to the other, at a height just taller than an ice jug. This dowel is removable. Place the first two ice jugs on the bottom of the Ice chambers, then insert the dowel through both Ice Chambers. Now place the other two jugs on top of the dowel. Short lengths of dowel can be used to "plug" these holes when only using two jugs if desired (the hole in the Baffle need not be plugged).

This technique has an advantage to simple stacking of the jugs. I've had trouble (as have others) with periodic rupturing of the lower jug from the weight of the upper as the ice melts and the jug becomes flexible. Using the dowel approach keeps the weight of the upper jug off of the lower. Another tip is to use bleach jugs, which are much stronger than milk or water jugs.

Using the Chiller

Set the Chiller in a convenient location, with the Front end accessible for monitoring fermentation and for loading and unloading the fermenter. Remove the Top and Front panels. Place the fermenter in the Fermentation chamber. Place one jug of ice in each Ice Chamber (tip:

bleach jugs are much stronger and will last longer than water/milk jugs). Set the thermostat to "cool" and adjust the thermostat temperature to that desired for fermentation. Plug in the AC adapter. If the air in the Fermentation Chamber is warmer than the thermostat setting, the fan should start running. Install the Top panel with the dowels. Check that cold air is blowing out of the fan or the intake port (depending on which way your airflow is directed). Install the Front panel using the dowels (sort of "scoop" it into place to avoid dragging across the weather stripping on the top edge of the Front panel). Eventually the fan will shut off, when the Fermentation Chamber temperature matches the thermostat setting. Monitor the operation and make any thermostat adjustments necessary to home in on the target temperature. The fan will likely cycle frequently at first, as the air cools and warms rapidly while the wort is still warm. Soon the fan cycling will be quite infrequent. As the ice melts, the cycling will increase in frequency. When the fan cycles frequently or runs continuously, when the ice is mostly or totally melted, or just whenever you feel like it, replace the ice with two fresh frozen jugs.

Great Big Fun

Good luck with your Chiller! I think you'll find it improves your brewing significantly, especially if you're not using any temperature control at all right now.