How to build a safe, effective wood-fired hot water heater

(A couple of Issues ago I touched on this subject, but it was a surface effort and contained the questionable suggestion that you could use a car radiator as a woodstove's hot water storage tank This is a more in-depth, more correct attempt by Don Fallick of Davenport, WA.—Dave)

By Don Fallick

The very simplest wood-fired hot water "system" is a pot of water on the back of the stove. It's cheap, simple, and safe. It's also hard to heat up a lot of water at once that way. It's labor intensive. And the water cools off fast when the fire goes out.

My family lived this way for three years. Now we have a closed-loop system that provides plenty of hot water from normal cooking and heating fires.

The trade-off is in greater attention to safety. In an open system, like a pot on a stove or the hand-filled tank in figure 1, water temperature is limited by its boiling point. Barring clogged pipes or boiling the tank dry, there's little such a system can do to you. This is not to say it's completely safe; at 212 degrees Fahrenheit, it is plenty hot enough for serious burns.

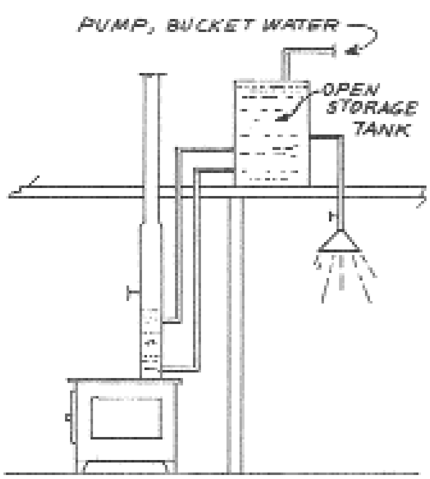

Figure 1.

But the real danger comes when you enclose the system, which can allow temperature and pressure to rise above normal boiling.

Safety considerations

If you've ever used a pressure cooker, you know that increasing the pressure even a little allows **much** higher temperatures to develop, high enough to cook food in a fraction of the normal time.

High temperature steam can also cook you in a hurry. And as the temperature increases, so does pressure. Left unchecked, it can blow ordinary water pipes apart. To prevent this, water heaters are built with a **temperature and pressure relief valve**.

This device automatically opens if the temperature or pressure exceed safe limits. For around $10 it's cheap insurance. I have frequently seen home-made hot-water systems without safety valves. This is folly.

Plastic, iron, & copper pipe

Preventing explosions is not the only safety consideration. Hot water is a much better solvent than cold water. That's why it cleans better. It also dissolves chemicals in pipes better. That's one reason for using "bone" colored plastic CPVC pipes for hot water, instead of the cheaper, pure-white, PVC pipes. There's also special glue for CPVC pipes that won't dissolve in hot water.

Iron pipes will rust fast in hot water if not galvanized, but use plain iron where pipes are exposed to flame.

Hot water quickly dissolves lead out of solder, too, so it pays to use only "lead-free" solder for joining copper pipes. (See BHM #8 on the danger of lead in water.)

If all this seems scary, it's meant to. It's really not difficult to build a safe, reliable, cheap, hot water system. But you need to know what you're doing.

Hot water systems come in three basic types, depending on how heat gets into the tank.

Heated directly by fire

Figure 2 shows a water tank heated directly by fire. I built such a system

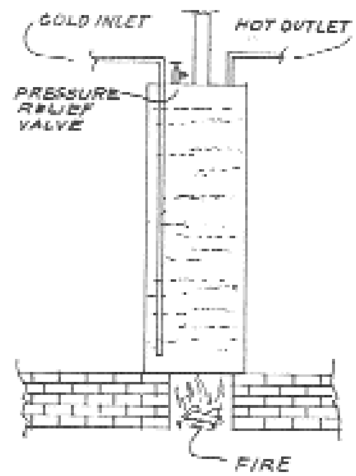

Figure 2. Water tank heated directly by fire.

as an experiment. It didn't work very well. My neighbor-Peter Hammil built a much better one. A comparison might be instructive.

We both began with recycled **gas** water heaters, which are designed for direct flame on the bottom. I used mine pretty much as it was after removing the gas burner. Natural gas doesn't produce much smoke, so the 4-inch diameter stovepipe in the center of the tank works fine…for gas.

For a hot wood fire, there's just not enough room for the smoke to get out. The choice is to build small fires or let the smoke choke the fire. Some choice! Also, the tank I used had a lot of lime and sand in the bottom, which slowed down the water heating even more.

Peter was smart. He used a torch to cut out the original smokestack, cleaned out the tank thoroughly, and welded in a length of 6-inch diameter steel pipe. He 16ft a stub sticking out to attach a regular stovepipe to. With a proper flue, Peter can heat a tank of water as hot as he likes in an hour or less.

I had cut the bottom out of a leaky, old wringer washing machine, cut a hole for a door, and turned it upside down for a firebox. It was way too big for the fire I needed, and the sheet metal door I made for it didn't work very well. I rested my firebox on bare earth. This was not a suitable foundation for a 300-pound water tank. I had to tie the tank to a post to keep it from falling over on someone. Even so, I never felt comfortable around it.

Peter had built a proper foundation. Then he set a short length of 18-inch diameter iron pipe on it vertically for a fire-box. The tank fit perfectly on top of it. With his torch he cut out a door and welded on hinges and a flange around the door. He even made a screw-type draft control, just like on a woodstove. It's a real thing of beauty, but more important, it works. Peter's tank is outdoors. He uses it as an open system, filling it before each use and draining it afterward.

Indirect water heating

It's more convenient to use heat from a woodstove to heat your water. There are three ways to get heat from a woodstove into a hot water tank. You can pipe water directly through the firebox, or you can run it through a coil either in or around the stovepipe.

Which one you choose depends on many factors. It may not be easy to run pipes through your particular stove's firebox. Cast iron can be real difficult to cut a hole in. If you must drill cast iron, use a **slow** drill speed. Make sure the metal is not cold. Castings can chip or break easily and are impossible to fix. Welded steel plate is very tough to cut without a torch. Sheet metal is easier to drill, but harder to caulk safely.

Exact pipe location

The exact location of the pipes is also important, especially in a cookstove. Improperly located pipes may interfere with the draft, catch a lot of soot, or make the stove hard to clean. Too much pipe in the small firebox of a range may leave little room for firewood.

I wish I could be more specific, but even books about woodstoves don't have room for more than a few examples. Figure 3 shows a view of the interior of my stove's firebox as it would appear if the left end of the stove were removed. It's a modern, Washington Stove Works' "Alaska" model cookstove with a **very** roomy firebox.

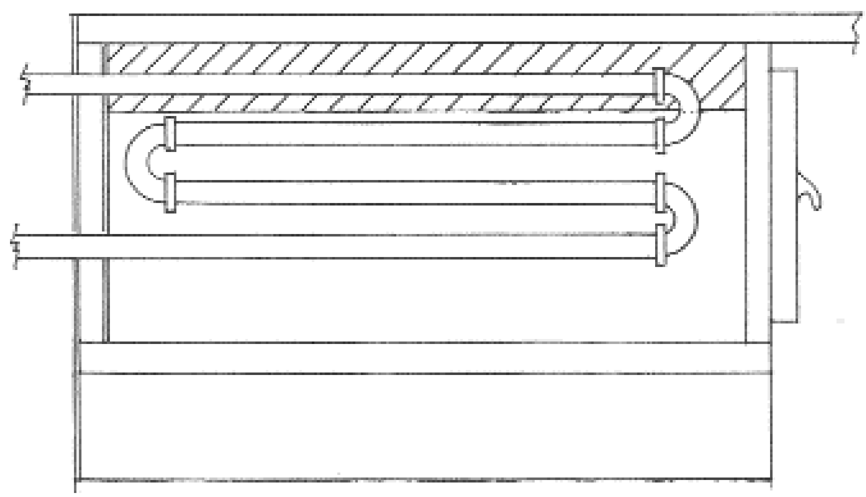

Figure 3. Cast iron pipe arrangement inside a firebox.

In it is a "W-shaped", double loop of 1-inch diameter, plain iron pipe. The pipes enter the firebox at the rear through holes drilled with a heavy-duty, 1¼-inch hole saw. The holes were drilled through both layers of sheet metal and later caulked with stove cement. They don't leak.

The pipes were placed at the oven side of the firebox, where the draft draws the flames past the pipes. The shaded part of figure 3 is the area where smoke travels over the top of the stove. As you can see, the top pipe does interfere with the draft. To lessen this interference, the pipes are placed about an inch away from the side of the firebox, allowing the draft to circulate on both sides of the pipes.

This further restricts the size of the firewood we can fit in there. But the firebox was so big originally that it hardly matters. I can still get a 6-inch by 24-inch log in! For smaller stoves, you'd probably want to use a single loop of ¾-inch or ½-inch pipe. Our stove will heat 30 gallons of cold water to near boiling in an hour and a half.

An Irish idea

My neighbor, Martin Palmer, lived for many years in rural Ireland. He says many cookstoves there have a hollow, brass reservoir at the back of the firebox, instead of the loop of pipe, and they heat water much faster. The reservoirs are quite expensive, being made of brass. Copper is too soft, and reacts with any iron it touches, causing both metals to decompose.

I have a 90-year-old Home Comfort cookstove we use for canning that I've been wanting to plumb for hot water for years, but I never could figure out how to do it. There are a couple of covered ports in the back of the firebox that are obviously intended for pipes, but 1 haven't been willing to drill through the cast iron firebox liner. Also, the diagonal placement of the ports puzzled me. Pipes run through these holes and connected with a 180 degree bend would completely block the firebox.

After Martin told me about Irish stoves I figured it out. The rear casting is removable, and can be replaced with a reservoir! The diagonal placement of pipes is exactly what you would want in a reservoir to promote water * circulation. I'm going to see what it would cost to have one made up by a local machine shop.

"Flue robbers"

An alternative to cutting holes in your stove is to remove some of the heat from the flue with a coil of copper pipe, either inside it or wrapped around the outside. There are advantages and disadvantages to this approach. Pluses include recycling of "waste" heat and no chance of damaging an expensive stove. Installation is the same for all kinds of stoves, and you don't have to work with iron pipe, which some people find daunting.

On the other hand, it's difficult to make a "flue-robber" work well, without making it work **too well**. Heat is what powers a stovepipe's draft; remove too much and it won't draw right. You'll get excessive soot and creosote.

Heat also dries up the water vapor and pyrolytic acid that are normal products of combustion. When the creosote does dry out, it can start a chimney fire and turn your house into a blast furnace in seconds. That's why I don't use a "flue-robber". Today's air-tight, highly efficient stoves are designed to emit just enough excess heat to draw properly. There just ain't much to spare.

If you are running a drafty, old stove that shoots plenty of excess heat up the chimney, it may be safe to use a stovepipe coil. They've been around a long time. One of my neighbors has one that's about 20 years old. It consists of four loops of 3/8-inch, copper pipe, coiled around the outside of the stovepipe. Coiling copper tubing perfectly-so it touches the stovepipe at all points-is an art I haven't mastered.

The thermosyphon effect

One thing all these indirect systems have in common is they all work on the thermosyphon principle. Rising hot water pushes previously heated water into the tank and draws cold water from the bottom of the tank into the lower end of the heat exchanger.

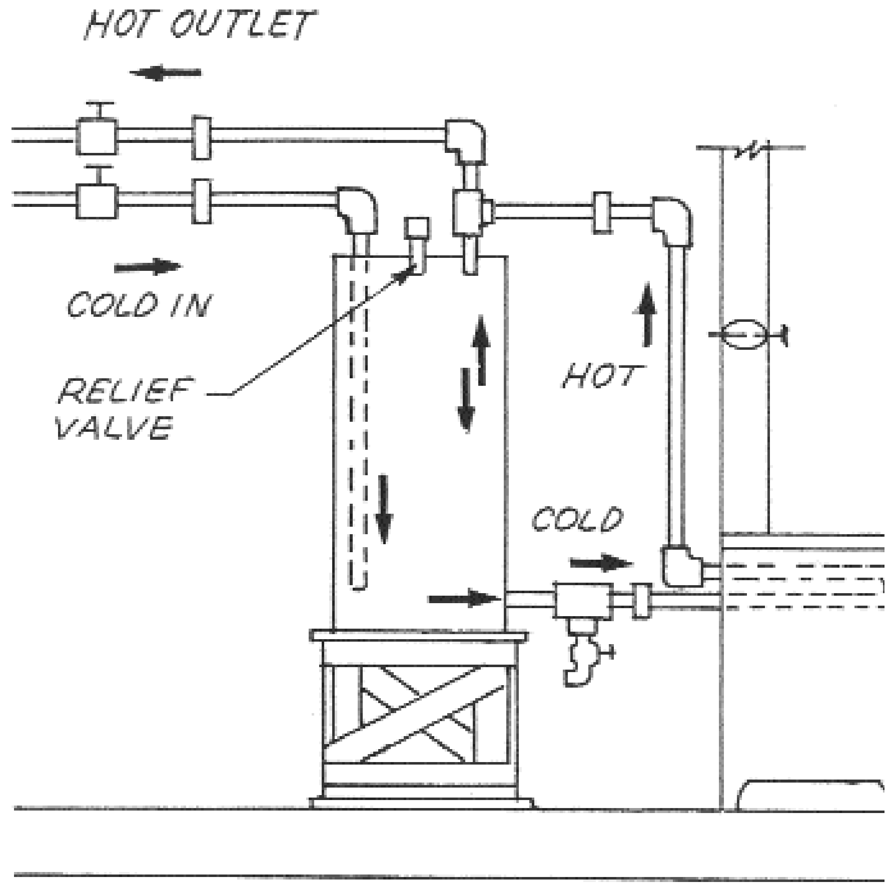

Figure 4. A properly plumbed system.

Figure 4 is a schematic drawing of a properly plumbed system. Note how high the tank is mounted. If the tank were mounted any lower, cold water from the bottom of the tank would have to rise to get into the stove.

A column of water exerts a downward pressure of about 1 psi (pound per square inch) for every 2.2 feet of rise, regardless of the pipe diameter. The thermosyphon effect is not strong. If it has to pull cold water uphill, it won't work. It's OK to have the tank outlet level with, or higher than the stove inlet, though. Lots of folks put their tank in the attic.

Let's look at figure 4 and see how a properly plumbed system works. Beginning near the upper left, we see cold water entering from your source. First it passes a **valve**, so you can shut the system down for repairs, then a **union**, which connects pipes the same way garden hoses connect. This allows removal of parts for repair or modification without tearing the whole system apart. Note-that the valve is on the **supply** side of the union. Next comes an **elbow**, then the **cold water inlet**, a pipe inside the tank, extending nearly to the bottom. Some water heaters have an external cold water inlet near the bottom of the tank. I have seen tanks with as many as five openings on top. If you can't tell which is the cold water inlet, remove all the plugs, caps, and other hardware and shine a flashlight down each hole in turn, while peering into another one. Light from the cold water inlet will make a small circle on the bottom of the tank. The others will illuminate the whole bottom.

At the lower right of the tank in figure 4 is the **stove supply**. In its original incarnation as a gas or electric water heater', this was the **drain cock** (or valve). Since we still need a drain somewhere, we must insert one in the lowest part of the system. So we put in a **tee**, and screw a **hose bib** (a faucet) into it. Between the tee and the stove is another union.

Theoretically, all these pipes except the stove supply are cold water pipes and could be made of any standard pipe material, even plastic PVC, but I don't recommend it. All pipes beyond the first union should be made of heat-tolerant materials **only**—metal or plastic CPVC. There is a rare condition that can occur in which the thermosyphon works backwards. If this happens, you'll be glad that all the pipes in your water heating system can take the heat. I have seen ordinary plastic pipe fittings deformed by hot water until the pipes burst apart. It's not funny.

Within the stove itself are two **plain** iron pipes (not galvanized) joined with a **180 degree bend**. Avoid using galvanized pipes in the firebox. The fire can burn off the galvanizing. The upper of the pipes in the stove is joined with an elbow to a vertical pipe, the **hot water riser**. This is joined with another elbow to a union, then to the tank with a tee. When the fire is lit, but no hot water is being used, the hot water leaving the stove through the riser reenters the tank, sucking relatively cooler water from the bottom of the tank into the stove supply, and repeating the cycle until the whole tank is full of hot water. When hot water is being used, it is drawn from the top of the tank, through the tee and another elbow to the **hot water outlet** pipe. This connects to the hot water **distribution pipes** in your house by a union and another valve. This time the valve goes on the distribution side of the union.

Will your floor support the water weight?

A typical, 30-gallon, water heater tank weighs about 300 pounds, filled, so it's **imperative** that it be mounted on a **sturdy** support, and that the floor under it be strong enough to take the weight. If there's any doubt about the floor's strength, place the support legs on boards (2 x 4 or larger), long enough to span at least two floor joists. It's not a good idea to use plywood or particle board, as they deteriorate when wet.

Pressure relief valve

Finally, note the temperature/pressure relief valve in the center of the tank top. This is more than just a "temperature" or a "pressure" relief valve. You want **both**. If it ever does release, steam and hot water are going to spray out of the valve. These valves are threaded so they can be connected to pipes, and the spray directed somewhere safe. In commercial installations, they are usually piped to a floor drain. For a home-brew system like this, a plastic bucket will do…if you are there to turn off the water! Moral: don't leave a home-brew system running unattended.

Variations…

The system just outlined is not, by any means, the only way to hook up a water-heating stove. In fact, each installation is unique.

My friend, Jeff Moore, mounted his tank on the roof, in a box insulated with four inches of rigid foam. An openable south side reveals the black-painted tank behind a layer of glass. Behind the tank is a curved reflector made from plywood covered with aluminum foil. Voila! A cheap and easy solar water heater when it's too hot to use the stove, and an outdoor, insulated tank for his woodstove to heat in the winter. It works, too.

All water has some air dissolved in it (or fish couldn't live). Heating water frees some of the air. If there is no way for air to get out of the pipes, it will rise to the highest point and stay there, blocking the pipes. Pipes arranged in the shape of an upside-down "U" (see figure 5) will not allow hot water to enter the tank. It will just keep getting hotter and hotter, until it turns to super-heated steam. Eventually, either the relief valve will blow, or the pipes will.

Tom Weinert, who built my hot water system, got tired of air in the pipes and added a hose bib at the highest point of the system. It did wonders for eliminating air in the lines. This can be caused by running the stove a lot, but not using much hot water. I bought a $10, high-temperature, bleeder valve to replace it when the rubber faucet washers died.

Authors of a book titled *Blazing Showers* (now out of print) say the horizontal distance between the stove and the tank should never be greater than twice the vertical length of the hot water riser. I guess if you put your tank in the attic, you could have a horizontal distance of 15 feet or more! I have never seen an installation which came anywhere near this ratio, but it's nice to know. Most folks instinctively try to minimize the distance from stove to tank, if only because pipe is expensive. Vertical distance doesn't seem to matter, as long as there is some.

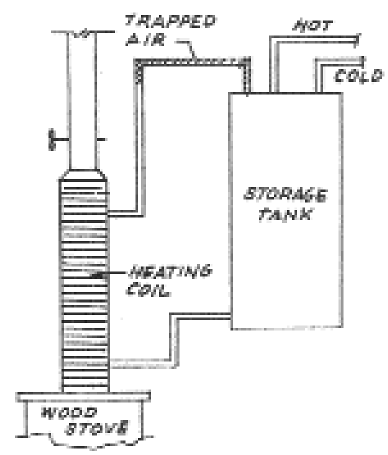

Figure 5. Trapped air in shaded area of pipe will prevent water from flowing.

…and cautions

You may wish to use copper pipe in the firebox. I can't recommend it. Even at room temperature, copper is easily deformed. When heated, it bends very easily. If you bump it with a piece of firewood, it could crimp, restricting the flow. Copper "work-hardens" very rapidly, so it would be easy for a crimped spot to develop a leak.

If you do use copper pipe, do not join it directly to iron or galvanized pipe. Copper touching iron in the presence of water makes a sort of primitive electric battery, producing **electrolysis**, or electrical deterioration, of both metals. Brass will not react with either copper or iron, so make sure there is a brass fitting between any copper and iron pipe. Regardless of what they're made of, all screwed connections should be sealed with **pipe joint compound** or **pipe tape** to prevent leaks.

If it's ever necessary to use the stove when the water is off, shut off all the valves in the hot water system and disconnect the union between the hot water riser and the tank. Running the stove with no water in the pipes is not really **good** for the pipes, but it probably won't damage them. You will get flame-hot air out the end of the pipe, though, so make sure it's pointed somewhere safe. Check carefully for leaks when you reconnect.

Finally, hot-water pipes are **hot**. If they're even remotely accessible to children or thumb-fingered adults, it's a good idea to insulate them if only to prevent bums when someone grabs the wrong pipe. It might be me. Δ

The second day of July, 1776, will be the most memorable epoch in the history of America. I am apt to believe that it will be celebrated by succeeding generations as the great anniversary festival. It ought to be commemorated as the day of deliverance, by solemn acts of devotion to God Almighty. It ought to solemnized with pomp and parade, with shows, games, sports, guns, bells, bonfires, and illuminations, from one end of this continent to the other, from this time forward, forevermore.

John Adams (July 3, 1776)

An original song…

They Never Got Johnny

Johnny Dillinger made robbin' banks
Look as easy as pie
& He made the law look like Keystone cops
Even Hoover and his FBI

Well Edgar the Hoov had to make a move
He was fit to be tied
Called Johnny Number One Public Rat
& Swore that he would die…

They never got Johnny
No, never got Johnny
How do I know that's true
The man they got had brown eyes…
Johnny's eyes were blue

When Hoover's boy Mel Purvis learned
Where the gang had hid
He traveled like hell to get there but
Later wished he never did

O the Hoov hit the fan when he found out
What happened that day
Purvis gunned down two innocent men
While the Dillinger gang got away

(chorus)

The Lade in Red saw a chance for some bread
& she called the Feds
"I know Johnny quite well," she said,
"What's he worth to you dead?"

It was over a hundred that day in Chicago
At the Biograph
The Lady in Red nodded her head
And bullets wrote his epitaph

(chorus)

Nervous Purvis would up on a cereal box
The Post Toasties Fed
But when the nightmares just wouldn't stop
He shot himself in the head

Mr. Edgar the Hoov hung a death mask
Of Dillinger on the wall
Those who knew the truth—what did they say?
They said nothing at all

(chorus)

Hamden, CT