PRODUCER GAS SPACE HEATER USING NATURAL DRAFT

The revision date of this documentation is 09-05-2008

For the sake of historical continuity, I'm adding the latest modifications to a separate section further down. Please skip down to 'SUMMER – 2008' if you have read the older file and are only interested in the latest revisions. This project has been a labor of love and warmth, :-) for some years now. I'm pretty satisfied with the performance and the durability of this unit and I think that further development will happen at a slower pace. The areas of shortcoming that I can identify are:

the seal of the top loading door,

ash removal,

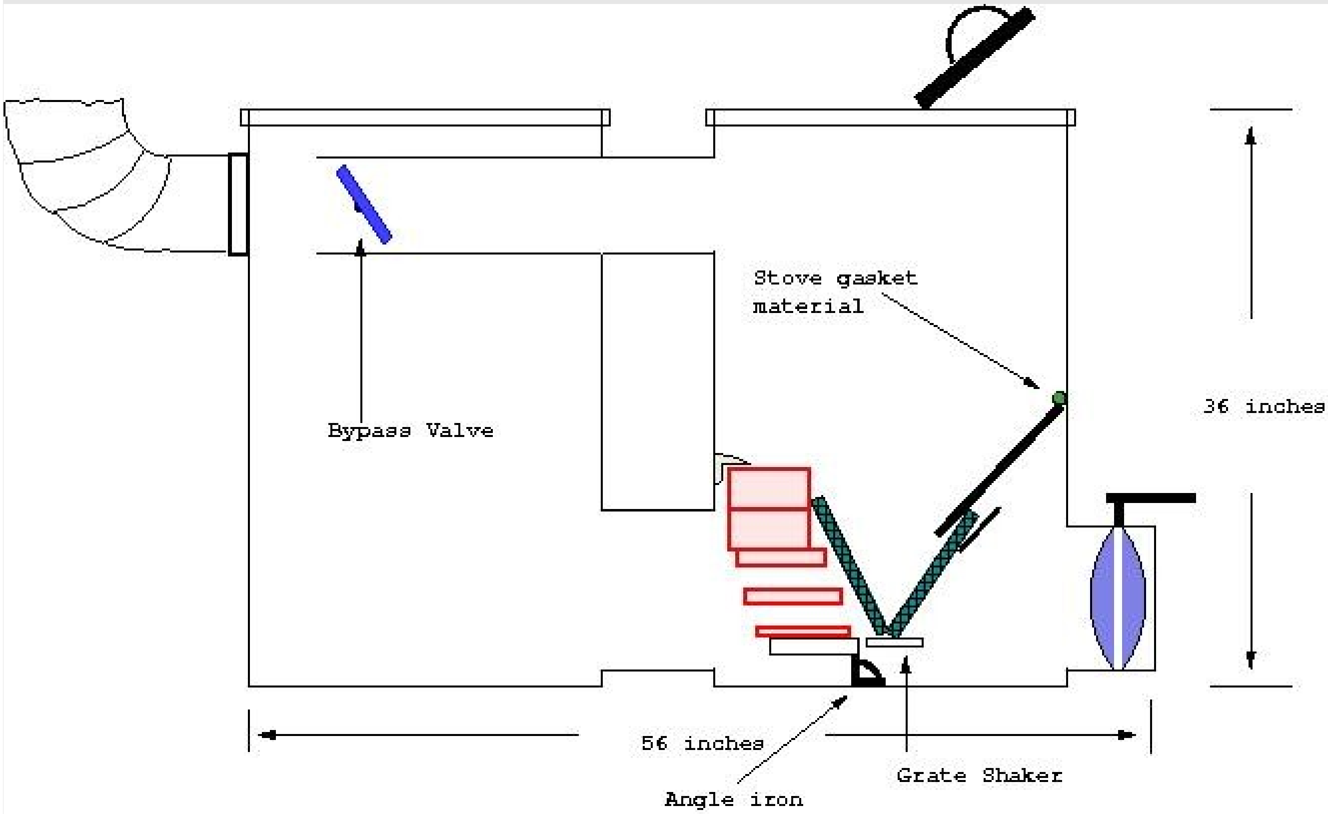
and fuel capacity limitations.

To all of you folks who are in the business of building wood gas space heaters, please feel free to use any of the ideas developed here. Just remember that any of the original concepts that I have developed are part of the public domain and may not be patented.

For the benefit of all you first time do-it-yourselfers; don't be afraid to use what you have at hand. 50 gal. Drums are thin but they can last a long time if you don't burn them red hot every day. I have a double drum stove that I built when I moved into my little cabin about 17 years ago. It's only now due for a re-build. Use the general proportions that you see in the drawings and you won't go too far wrong. There is nothing magical about wood gas. If you are building from steel plate please design in greater ash collection capacity and add a fire tube tunnel using fire bricks for longer life. If you need a cook stove then cut down on the height of the second drum and add a sturdy cooking surface. Add an air or water heat exchanger and you can put the stove in an out building and transfer heat to your house. While you are at it, add to the volume of the fuel hopper and you won't have to trudge out through the snow to re-fuel so often.

“Old” documentation starts on the next page.

DRAWING BELOW IS A VISUALIZATION OF THE MAJOR COMPONENTS

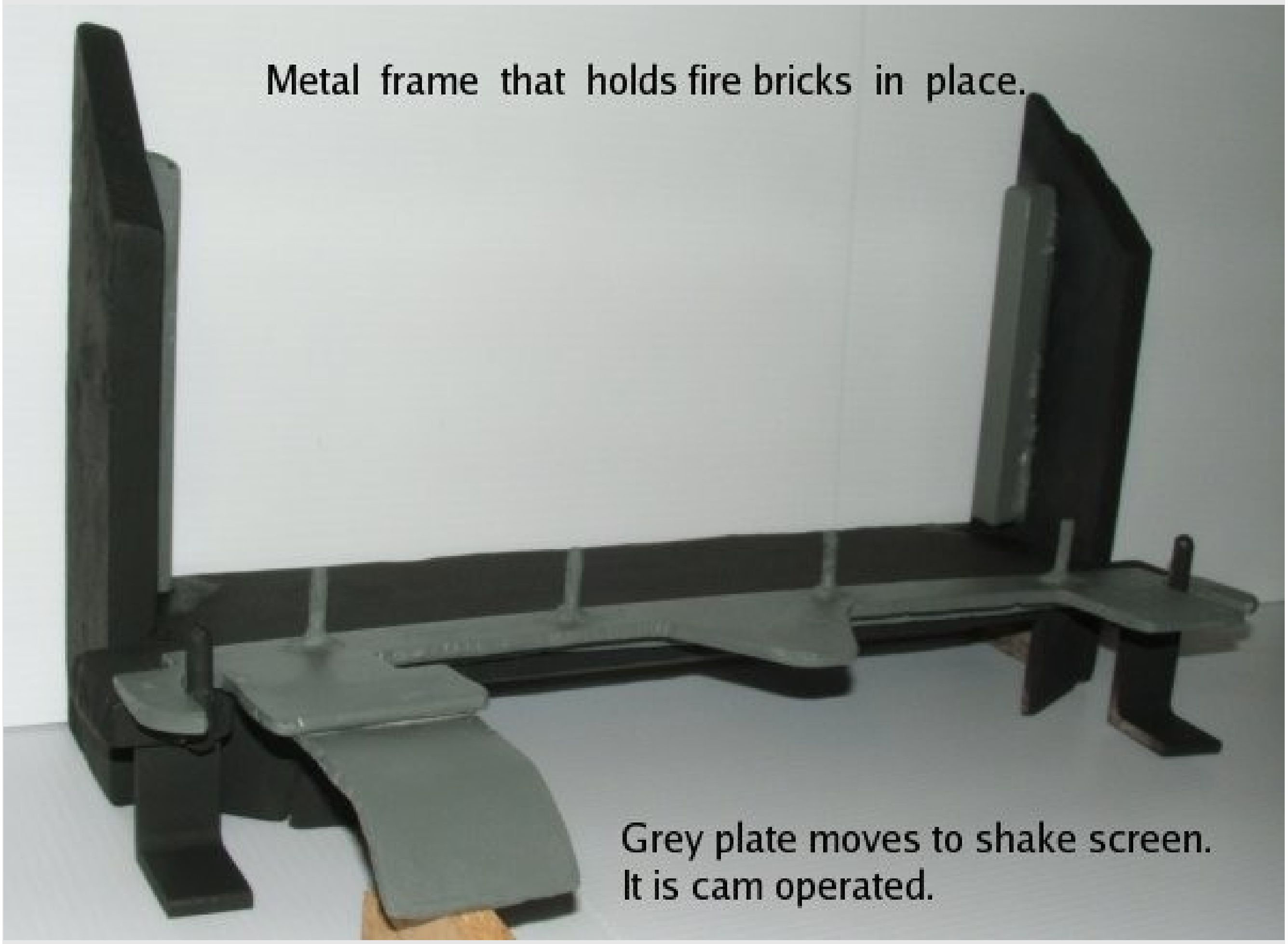


What we have here is basically a cross draft gasifier that creates enough heat in the bed of hot coals to pyrolyze the woody fuel above it and then reduce the resulting fumes to a clean burning gas. There is no separate primary air control. We don't need one. Some of the draft air circles up into the pyrolysis area and helps create the 'dirty' gas and vapor that is then sucked into the bed of coals. This thing is so simple, it's amazing. Of course it didn't start out that way. Early incarnations of this heater used tuyeres, a restrictor plate, a stirring mechanism and an electronic timer. It has taken years of trial and error to get to where we are today. Simple is good!

We started out trying to use several tons of splitter refuse as fuel. Splitter refuse is usually thrown away. I had tons of it because I was in the fuel wood business several years ago. Being a thrifty fellow, I didn't want to throw the stuff away. Trying to burn it is problematic, to say the least. Anyway, in the course of various attempts over the years at making a clean burning, gasifying space heater, I used all that trash up. It got burned, but not always smoke free. Well, guess what? This critter will burn that stuff, smoke free, if the sawdust is screened out and if it is dry. It will burn 2X4's, dry branches, thin splits, chunks and any small dry dense biomass. Max size is generally about 16 inches long with a max diameter of 3 inches. I have to work harder to split wood down to that size, but I get more heat from it and it burns without pouring a lot of smoke into the air.

PRODUCER GAS BURNER FOR SMALL LOGS, CHUNKS AND CHIPS

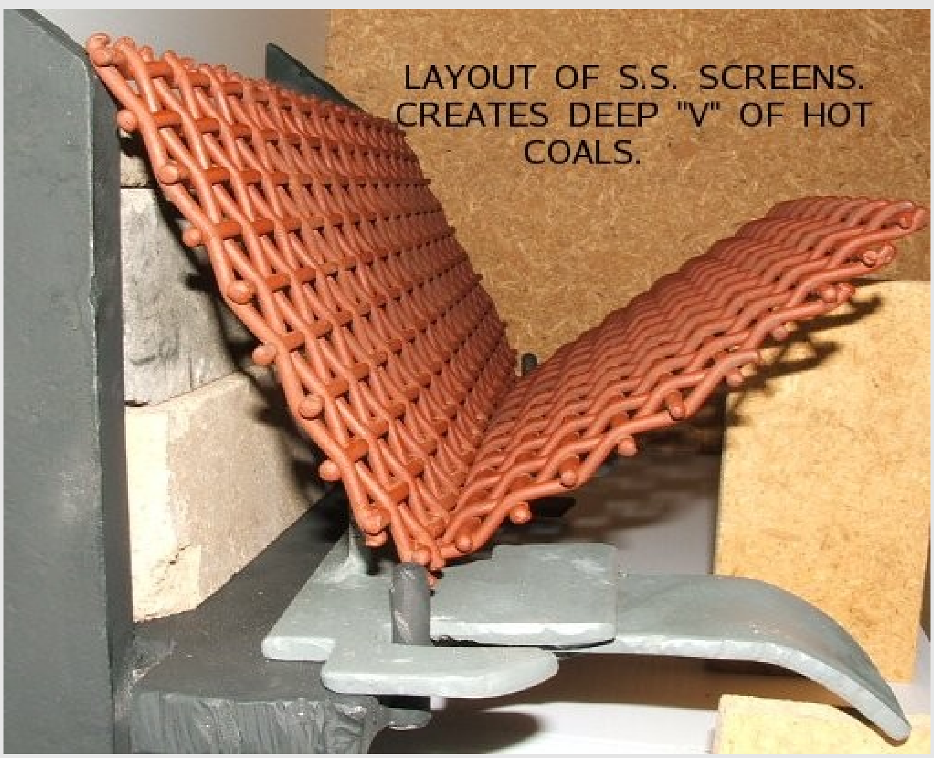
We are using Fire Brick to restrict the size of the opening that the burning gases can go through. This creates an upper limit to the amount of heat that can be produced. It also ensures that the stove will have a longer useful life than if ordinary steel is used where the flame impinges.



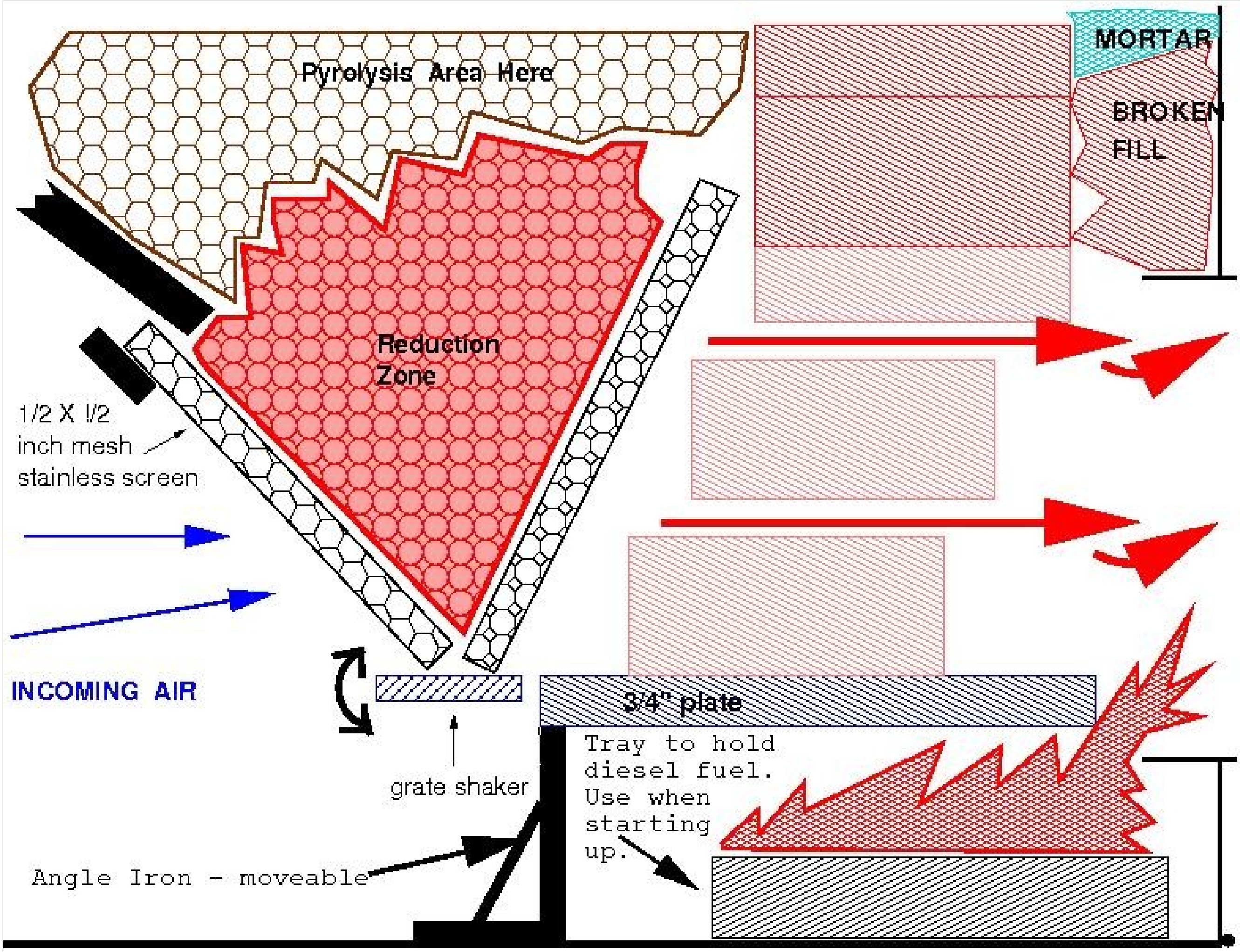
I welded up a frame of 3/4" plate that holds the fire bricks in place and prevents the products of combustion from going around the stack of bricks. The bricks are slotted on their sides to stay in place. They are stepped back so that the hot coals and ash will drop down into the apex of the reduction area. Slices of fire brick are used to create the openings through which the flames flow. The size of the openings determines the heat output of the burner. This is the big conceptual breakthrough that I needed. Most of my earlier burner designs that worked well, produced TOO much heat for my small cabin. Now I can have the fairly large bed of hot coals that I need and control over the amount of heat produced. Also the fire brick burner does not warp and get oxidized from the heat.

Fire brick slices were cut with a 14" metal cutoff saw. It worked well. Could also have been done by using a ceramic cutoff blade in a skill saw.

Here you can see that the fire bricks are stepped back better than in the first view. The sides of the frame were sealed to the drum sides with stove door gasket material forced into the chinks.



Where the magic occurs. Pyrolysis vapor is converted to clean burning gas.



Above is a drawing of the burner. Vertical section is slightly off center. No scale given.

This is a trial assembly. It was re-done. It does show how the first s.s. screen sits in the slot of the screen support plate. Notice that the lower edge of the screen is behind the 'fingers' of the grate shaker plate.

Cam, low.

This is the cam that operates the plate that shakes the screen. It is operated by an outside lever. The cam shaft is supported by two bearings, one on each end of the pipe that protrudes into the lower stove.

Cam, raised.
The cam gives about an inch and a half of movement to the end of the grate shaker plate.

This is the handle that actuates the cam. It is fairly long to give enough leverage to lift a heavy load of fuel in the grate. Pulling the lever up smartly is supposed to clean the grates of ash. The other purpose in moving the stainless steel screens is to break up a 'bridge' in the fuel if one forms.

Side view detail showing steel pipe on top which is the bypass conduit.

The stainless tube on the bottom was formerly a soft drink syrup container. The flame passes through it to the second drum which is mostly a heat exchanger. The 'fire tunnel' has an inner liner of stainless steel, but it can still get red hot.

A hand formed exit coupler goes into a black iron standard 6" stove 90. The flue is double wall stainless. It helps to keep the heat in which works to increases the draft. I'm guessing that 25 % of the heat energy in the wood is used to create the draft. It takes a certain amount of air moving through the stove to make it work. There seems to be a 'critical mass' of heat that is needed before the stove works well. One could extract more heat from the exhaust stream using electric draft augmentation. But then, won't we be adding to greenhouse gas emissions by using coal generated grid power?

The largest diameter for a log that does not cause problems is about 2 to3 inches. Anything larger in diameter than that does not get pyrolyzed well and plugs up the works. Also sawdust does not work well. Sawdust blocks off the free flow of air through the burner and a "dragon fart" can occur. Trust me, when that happens it's tough on the eyebrows and the rug.... also makes the pets nervous. Use gloves and safety glasses when loading wood and making adjustments to the butterfly valves. Every part of this stove is HOT!

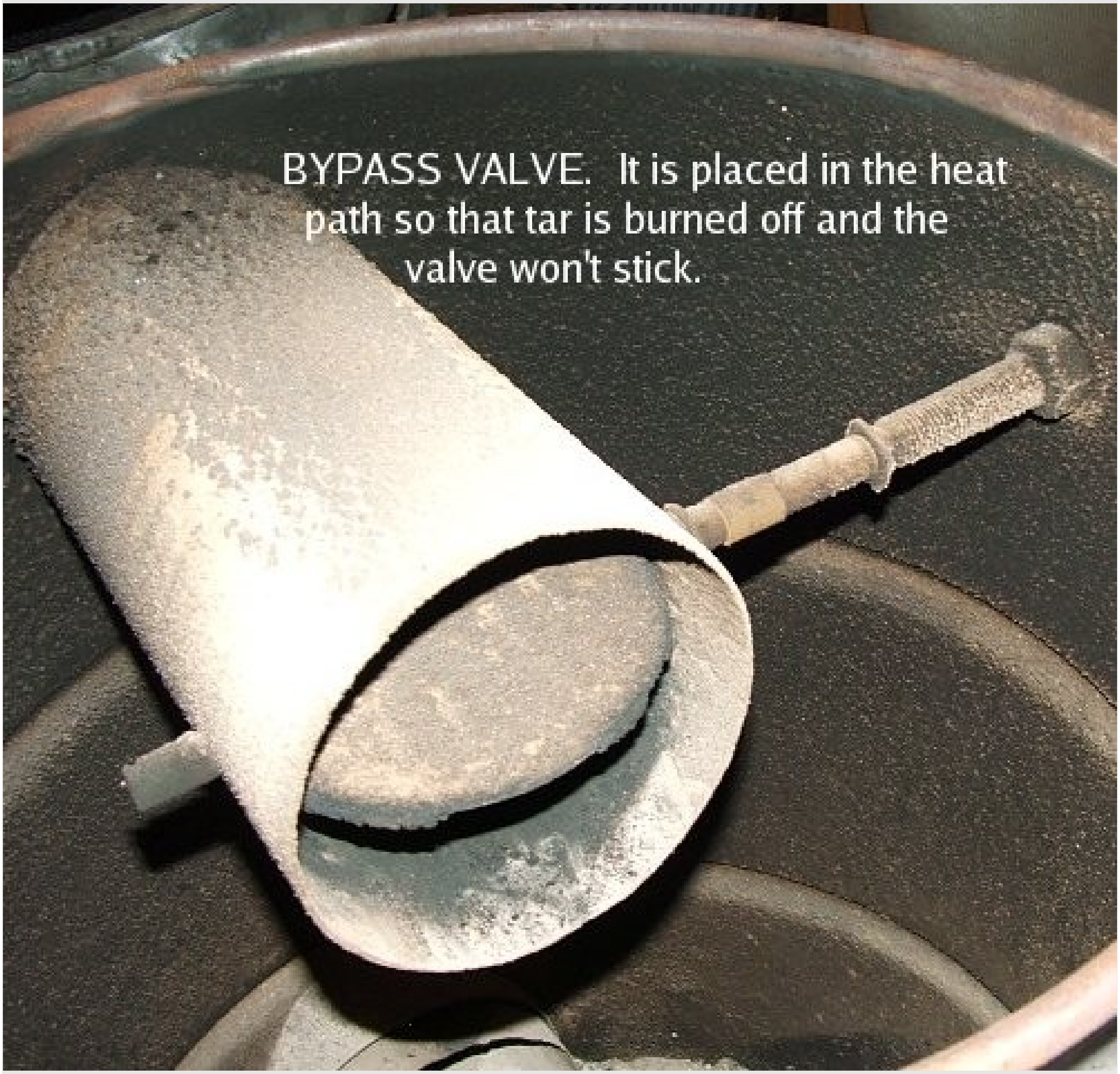
It can take about 15 minutes from startup till the stack quits smoking. How quickly you get a clean burn started depends mostly on the moisture content of the wood. If your M. C. is more than about 30%, fergittit.. the stove won't burn clean. I try and keep a bed of charcoal in the burner for the next startup by shutting down early and closing off all the air valves. It really helps to have the charcoal there at startup. When it's time to start up again, I shake the grate, clean the ashes out of the bottom of the drum, and put smaller splits above the charcoal. Then the rest of the fuel is loaded. Three or four ounces of diesel fuel is squirted into a cut down coffee can. The coffee can has some ash in it that soaks up the diesel. Squirt some diesel fuel on the charcoal facing you. The coffee can is placed behind the angle iron that closes off the air flow under the grate. The angle iron is set toward you a little so that the diesel in the coffee can will catch fire from the wadded up newspaper that we use to start the whole process. Three or four double sheets of wadded up newspaper are all it takes. A little squirt of diesel on the newspaper, a match and in a few seconds when the diesel in the cut down coffee can is lit we can move the coffee can toward the tunnel that connects the two barrels. This will create a good draft and helps to "eat" the early smoke which is not combustible. Move the angle iron to shut off almost all of the draft under the grate. This forces most of the air through the hot coals. You may want to keep the bypass valve open for a few minutes to give the bed of coals a chance to "grow" in depth. Doing this vents a lot of moisture and creates dense, white smoke. Do this when the neighbors are not looking. :-)The record shortest time that I have so far, from startup to smoke free operation is .... Ta, Da! ... 5 minutes!

Reloading while a batch is burning can be exciting if the proper procedure is not followed. Your stove may behave differently than mine and so these are just suggestions. First, shut the stove down for at least 15 minutes. Then open the bypass valve and wait a few seconds. Very slowly open the loading door slightly and wait till the air going in has purged most of the combustible gas and all of the smoke is going out the bypass. You can now open the loading door enough to drop smaller chunks of wood onto the coals and calm the fire down. After that you should be able to open the door fully and just dump buckets of fuel in, or place your logs in crosswise so that they will feed nicely. Close and lock the loading door and then open the lower air valve and close the bypass valve. That's it. Be forewarned! Just opening the loading door without going through the whole drill will fill your house with smoke OR cause a huge back- flash of burning gas that will not be kind to your whiskers. Use Safety Glasses and Gloves!

I usually pour some water on the top of the first drum to increase moisture in the house. I keep the water level constant by putting a pot of water up there with a 'wick' made of a twisted washrag hanging over the side. The water on top keeps the temp of the lid down and extends the life of the Silicone Rubber that the gasket is impregnated with. I need to do more work on the loading door. Tar builds up there and causes problems. When I get the bugs worked out on the loading door problem, I'll add the solution to the documentation.

Turndown, or modulating the heat output, is something that I am still learning about. It is best done after most of the moisture is burned out of a charge of fuel. When the house is toasty warm or the stove has been operating well for about an hour, the draft can be cut back and it will continue to burn clean with reduced heat output.

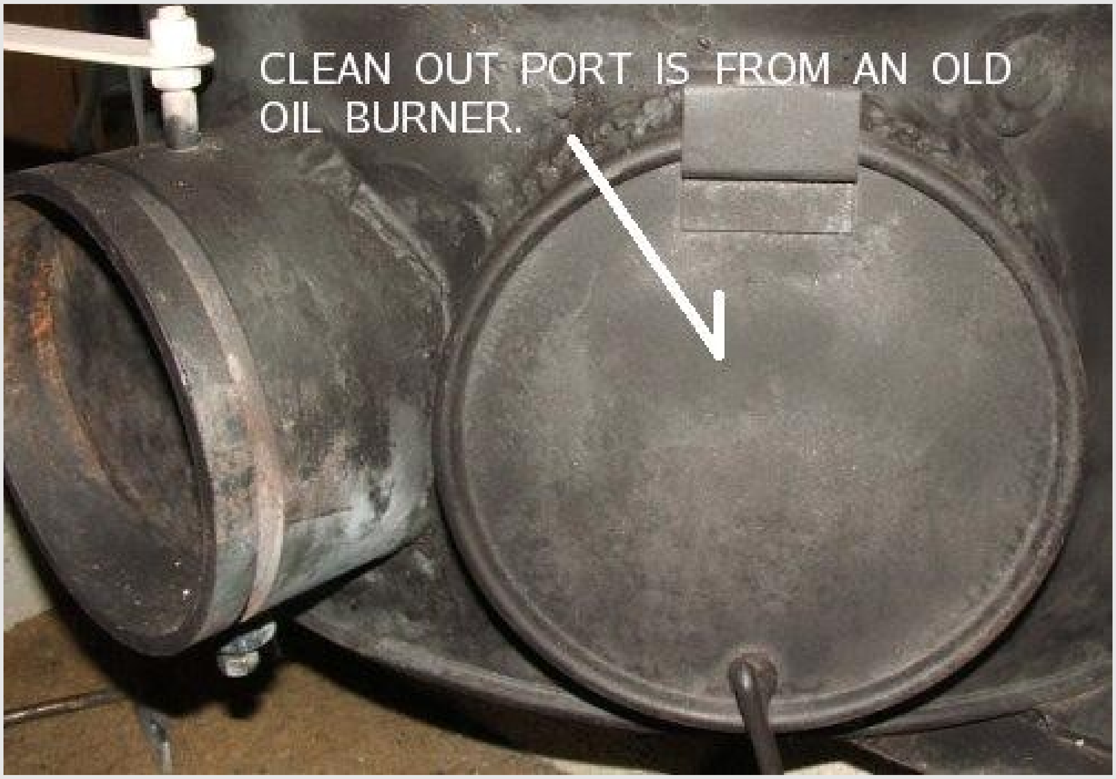
MORE CONSTRUCTION PHOTOS



The bypass valve allows smoke to go up the stack and is opened when reloading. It can also be used to let some of the moisture out of the fuel hopper when starting up. Careful though, the water vapor smells bad and the neighbors will think that you are trying to eradicate mosquitoes.

Bypass valve handle in fully open position. Crack the valve a tiny bit if too much moisture at startup keeps the coals too cool to produce good gas.

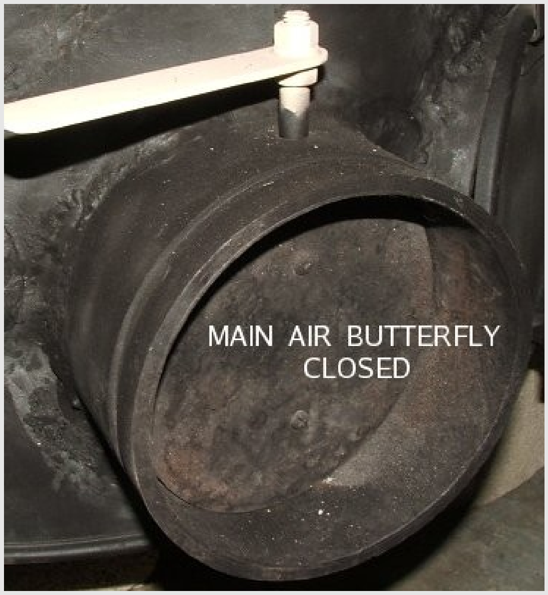
Bypass valve handle in closed position. Build this valve carefully so that the butterfly seals well and does not go 'over center.'



Main air and clean out ports.

The clean out port was liberated from an old parlor oil burner. I replaced the gasket with modern stove door gasket material. This is also the lighting port.

Main air butterfly valve open.



Strive for perfection in building the butterfly valve. Be willing to accept 'good enough.'

Standard Disclaimer:

Don't sue me. I don't have any money. If you build one of these units you are on your own. If you haven't used wood heat before, read Shelton's "Wood Heat Safety". Since this type of stove can release large amounts of smoke, soot and ash if operated improperly, I suggest that you learn to use it outside. Another suggestion would be to heat water with this unit in a detached out building and pump the water to radiators in your house. Check all your welds to make sure they are not porous. CO is dangerous. Get a CO detector for your house.

If there are any new ideas developed here, they are hereby put into the public domain and may not be patented.

PROOF OF CONCEPT "CHUNKER"

I added an auxiliary blade to my wood splitter because the original one won't go forward enough. There is a fence that slides along with the new blade that limits the length of wood that the blade will cut to about an inch and a half. The fence has a cut out that lets the chunked wood fall away into a bucket under the log splitter.

Chunker showing auxiliary blade.

Next is a view of the sliding fence and the cut out through which the chunks fall.

This is what the "product" looks like.

What we are looking at above is chunked "squaw wood." It is the lower dead and dry limbs of pinon trees. It is called "squaw wood" because a squaw usually gathered it using only her hands or by whacking it with the poll of a "squaw ax." (Single bit ax.)

"Squaw Wood" in the back of my truck.

"Squaw wood" has a low moisture content. It has usually been dead for a period of years and is still on the tree so that it has not picked up moisture from the ground. I measured the moisture content of various types of dead wood back in the 80's when I was fiddling with my wood burning Cadillac. What I found was that moisture content of dead snags and "squaw wood" was usually between 8 and 20 percent. Perfect for wood gas. What I would like to eventually do is construct a "chunker" that is automatic in operation and is oriented up and down so that the chunks fall down into a bucket.

By the way, back then I didn't have a log splitter. I made my fuel by cutting a round of dead, dry wood into a disk about two inches thick using a chain saw. I then put the disk on a chopping block and broke it into chunks with a hatchet. Kinda' slow, but it worked.

S U M M E R - 2 0 0 8

The big problem I've always had with the wood gas space heater is the amount of smoke it creates when starting up. This is due to too much moisture in the pyrolysis gas early in the startup sequence. Also at this time the hot charcoal bed is not large enough to 'crack' the gas into a clean burning product. Another variable is the heat robbing ability of the ceramic fire brick 'burner'. Once I isolated the problems, solutions were tested and the results seem to promise clean start ups that can be tolerated in an urban environment. Using clean burning propane and a common weed burner produced an almost smoke free start up. Now a weed burner is kind of a cumbersome clunk to use for an everyday start up. However, it proves that propane or natural gas can be used to provide the starting draft needed and also 'eat' up the problematic excess of moist pyrolysis gas. A built in starting propane gas burner of the 'atmospheric' type can be designed into the space heater. Another option is to build a small hand held burner and direct it through the lighting port for the few minutes it takes to get to smoke free operation. In any case, clean burning diesel or charcoal starting fluid can be used is propane is too big a problem. Just 3 or 4 oz. In a cut down coffee can will do the job. Unfortunately, diesel does produce some smoke by itself, so this is not the optimal solution. All of the testing this summer showed that we can start up and get to smoke free operation with a lot less initial smoke and none of the acrid smell that was formerly produced. The amount of smoke produced, starting up with diesel fuel is comparable to the amount of smoke that my barrel stove gives off when I start it. I do a top lit start and burn small, hot fires in the barrel stove because I have neighbors now. Of course, the barrel stove smokes most of the time and needs constant attention because the small fuel load only gives off heat for a half hour or so.

Anyway, on to describing the changes:

#1. An inclined shelf of 1/4” steel that isolates approximately half of the fuel load from the hot coal bed. It has a small lip welded on so that charcoal fines are retained to act as insulation. The shelf should be angled up so that fuel can feed down onto the burner area. Now this shelf retains a reservoir of charcoal than can be used for the next start up in case you didn't shut down early enough to save some charcoal. The main purpose of the the shelf is to cut down on the fuel exposed to the the hot coal bed and thus reduce excess pyrolysis gas. If the fuel feed was mechanical and not dependent on gravity there would not be a problem. The operator could just set the fuel feed rate to “low” at start up and then increase it later.

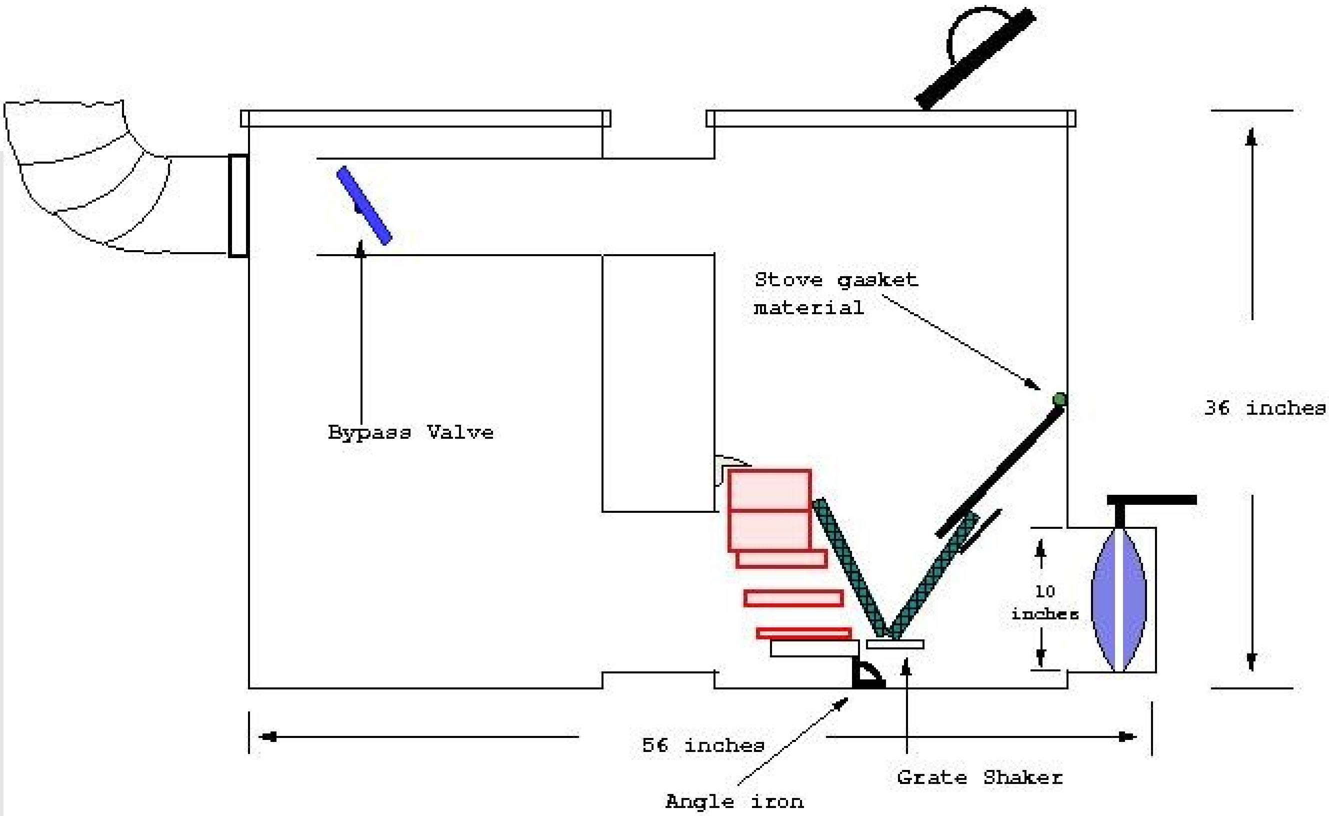
#2. A Fuel Shaker. A 1/4” plate that just hooks into the surface of the screen support plate. It is actuated by a rod between it and the grate shaker. Moving the grate shaker handle lifts the grate shaker and the rod transmits this motion to the fuel shaker plate. It is used when the fuel forms a “bridge” and is not feeding properly. Bridging can happen when small fuel interlocks or when a larger stick is not laid in properly. Bridging manifests itself when the heat output goes down and/or light whispy smoke comes out of the stack. It's not that big a problem, but it does happen.

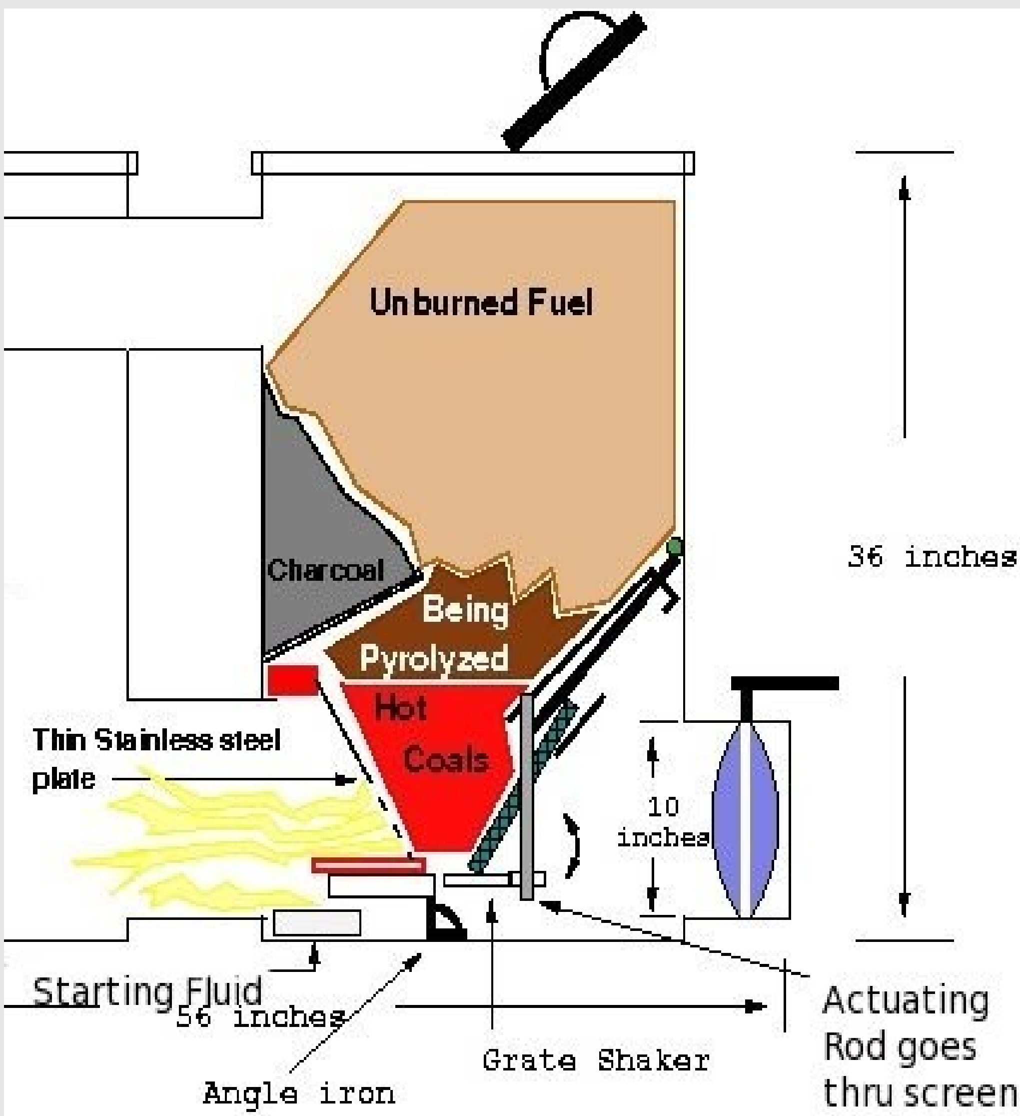
#3. Got rid of the fire bricks in the burner. Using fire bricks for the burner slowed the smoke free operation down by 'robbing' heat just where it was needed... the point of combustion. What I used is some stainless steel sheet (.025 inch) that was from a restaurant counter top or some such. It covers most of the area formerly filled with fire bricks. The openings through which the wood gas passed were just freehand cut with an acetylene torch. I didn't do a good job of measuring the total area of the openings. I'm guessing it's about 10 to 15 square inches.

Please skip down to the next page to see the before and after diagrams of the stove on one page.

The top diagram is “before”.

The bottom diagram is “after”.


Stove gasket
material
Bypass Valve
36 inches
10
inches
56 inches
Grate Shaker
Angle iron


Unburned Fuel
Charcoal
Being
Pyrolyzed
Hot
Coals
Thin Stainless steel
plate
36 inches
10
inches
Starting Fluid
56 inches
Grate Shaker
Angle iron
Actuating
Rod goes
thru screen

These are pictures of how well the stove works with three different start up scenarios.

This first group of pictures shows how things go using a common propane fueled weed burner. The weed burner was lit and introduced under the burner support frame after moving the angle iron off to one side. We let the weed burner heat things up for a couple of minutes to create a good draft and then we directed it on the cold bed of charcoal to get that going. Then back under the support frame to maintain draft and “eat” the early un-burnable smoke.

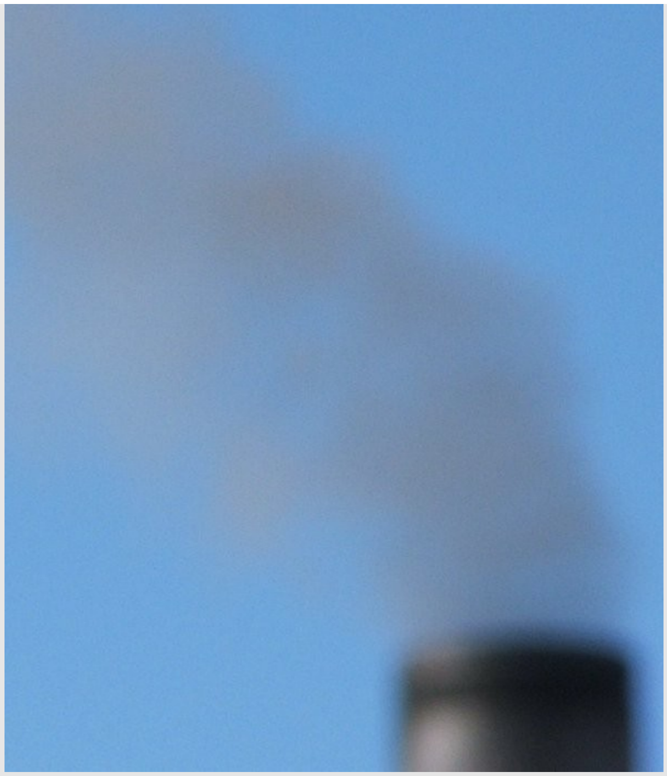
This picture shows the stack right after start up. I ran out and snapped the pic within a few seconds of getting the charcoal bed going. The hopper is full of fuel and there is a good charge of charcoal in the grate. This exceed all my expectations!

The stack for the wood gas heater is on the right. This is two minutes into the burn. The propane fueled weed burner is 'eating' all the smoke usually produced and not adding any smoke itself.

After five minutes... The weed burner is OFF. There is some slight smoke but the camera did not pick it up.

After 15 minutes. ... No visible smoke at all! And this with the morning sun low which would accentuate any smoke particles.

The next few pics show what happens if we start up with diesel fuel that was used to wash truck parts in.



Start Up. ... Yup, as expected, the dirty diesel adds smoke.

Two Minutes after start up. ... Not so much smoke now. This is still less smoke than starting the old un-modified setup. ... And the dirty diesel is free.

Five minutes after start up. ... Ugg! Still smoking.

Twelve minutes after start up. ... Still some slight smoke. Camera didn't pick it up.

Twenty minutes after start up with dirty diesel. No smoke at all. There sure is a big difference between starting up with a propane assist and using funky diesel. There's a lesson to be learned here.

O.K. This series of pics shows us using clean diesel to start up with.

Start up. ... Big gripe – I paid $4.59 a gallon for this stuff. Just used 3-4 oz., but that still irks me. There IS some slight smoke. Camera didn't catch it well.


Two Minutes after start up. ... Not too bad.

Eight minutes after start up. ... Morning sun accentuates smoke particles. If you look at the stack from another angle you won't see anything.

Twelve minutes after start up. ... Looking good.

Twenty minutes after start up. ... Looking SSE across the gulch. Morning sun was still low, so any smoke particles would be visible.

Hints revisited:

Use dry wood. This thing won't work if the moisture content of the fuel is much above 20%.

Listen! You can tell if the stove is operating properly by the slight roaring sound it makes.

Run the stove at full heat for about an hour and then cut back on the combustion air. It will then give off reduced heat and no smoke.

Good luck and stay warm this winter.