A First-Year Report
On Our Rocket Mass Heater
2023-2024 Winter Season

Boyd Weeks - Lamoni, Iowa

The Rocket Mass Heater (RMH) is arguably the most efficient way to heat a home and dirt cheap to build. I will explain how I built this one and how well it worked over one winter season. I will also explain some improvements that I am planning to implement for next season that I expect will make it run even more efficiently next season. A couple of these improvements may be new to those familiar with RMHs, so I hope you will find this explanation helpful.

Please overlook its appearance. I built it for functionality first and expect to take care of its cosmetics after the testing and improvements are complete for next season.

Pre-RMH – Standard wood stove with occasional natural gas

Summary:

- **60% heat or more escaping through the flue.**
- **Significant heating and cooling spikes over a 24 hour period.**
- **Soot settlement throughout the house was normal.**
- **Supplemental heat by way of natural gas wall unit used to prevent cold spike in house from dropping too low.**

Early in 2023, after noticing the amount of wasted heat escaping up the flue of my old wood stove that could be used in my house, I determined that I would replace it with a RMH. Thus, began my research and planning into this project that came to fruition a few months later.

Our house is a 100 year old octagon-shaped structure (29’ across) with a 16 x 10 foot bedroom extension that has been rebuilt throughout to modern standards. [860 sq ft] It has an original 10’ ceiling as well as an 8’ drop ceiling that was put in at some point before I bought it. I insulated both of these ceilings. The original stove and the new RMH are both placed at the center of the octagon portion of the house.

For the past several years, we heated the home with a model WS-TS-2000 Woodpro wood stove we bought at Menards for about $780. It was rated at 13,500 to 31,600 BTU/hr. For a wood stove, it worked pretty well, burning about 1.5 chords of wood over the course of the 2022-2023 season winter season, which was about average for us.

This heat was supplemented somewhat by natural gas, which kicked on when the temperature dropped below a certain point. This happened frequently on cold nights when the wood burned down low. During the coldest part of the winter, the temperature in the house often dropped down to 50-55 degrees before the gas heat kicked on.

A brief description of the RMH

The exhaust port for our wood stove was 6”, which I fitted to a 7” flue. The reason for the 7” flue was due to having some pipe on hand from a Pioneer Princess stove I had at another house previously. For this reason, I chose to build a 7” RMH system. In a RMH, it is generally important to keep the channel consistent in size from the wood feed all the way until it exits the roof.

There are some exceptions, such as the area in the barrel or the use of stratification chambers, which I did not know about when I first built this RMH. In my system, the horizontal burn tunnel in the core is a little bigger than the Cross Sectional Area (CSA) of the rest of the channel by a couple of inches, but I noticed no problems with it.

I will not go into all of the particulars into building a RMH here. For more details, I strongly recommend the book, “The Rocket Mass Heater Builder’s Guide” by Erica and Ernie Wisner. This was my primary reference for my build as well as several good web sites, such as Permies.com and several others these sources recommended.

I began to build our RMH on June 10, 2023 and completed it on October 14th, which is about just over 4 months of working on it off and on while doing other things. The total cost for materials was $664. Most of this cost was in the firebrick (100 for $343)

Beyond the firebrick, most of the stove is built out of cob, which is simply a mix of local clay and sand with a little straw mixed into it. Cob is surprisingly strong and seems more shock resistant than concrete. In some ways, it is even easier to work with and more forgiving. A friend provided me with the clay from his property where he was moving some earth to put a building on. The sand cost me $120 from the building supply and a bale of straw for $10.

Other materials included two used 55 gallon steel drums, $5 each, and some cheap HVAC duct and a couple of tees and elbos, most of which I already had in storage from some other project. Do understand that this is not the flexible duct, but the smooth, sheet metal type. Flexible duct will create to much drag on the draw and possibly be enough to prevent the stove from working properly.

I chose to build a J-style because it is simple in concept, however, it must be built within certain parameters in order to function. It is basically a J-shaped chimney wherein wood is fed into the lower end and the continuous chimney fire exhausts out of the higher end, which is called the riser. The riser is covered by a steel drum that directs the exhaust down into a half-barrel manifold buried within the cob, then into a cob bench through 7" HVAC duct before being exhaled through the vertical flue to exit above the roof.

The exhaust first heats the steel drum, which immediately radiates heat out into the room. However, there is still much heat in the exhaust. This left-over heat is mostly transferred into the cob bench where it is stored and slowly released over the next several hours. This effectively maintains a much more stable temperature in the house than a normal wood stove.

Unlike most fires that we see, this fire actually burns sideways as the draft thrusts the flame through a horizontal burn channel before entering the vertical riser. There is a constant air flow through the wood feed, so there normally no smoke that enters the room, unlike a regular wood stove that will blow out some smoke every time the door is opened. In our experience, there has also been little to no fine ash settling on our furnishings such as we have seen in past years with a standard wood stove.

First season of our RMH

Summary:

- **The RMH reduced the amount of firewood burned by 52.65% from the older wood stove.**
- **No supplemental heat used.**
- **More stable temperature in the house throughout the day.**
- **No detectable soot settlement in the house.**
- **Warm bench provided direct heat for those sitting on it.**
- **Some planned modifications for next season are expected to improve performance.**

As mentioned previously, I was first attracted to the idea of a RMH after observing that more than 60% of the heat produced by our previous wood stove was going up the flue and only heating the bird's feet outside. I don't mind being kind to the birds, but figured that they could do well enough without my help. A friend made a RMH when these stoves were early in their development, but he could not get his to work, so he gave up with it. It was the first time that I was introduced to the idea.

After giving it some thought on the amount of waste that I was experiencing with the wood stove, I determined to dig further into RMHs. I was certain that if I could capture that heat and use it in our house, we would not have to burn nearly the amount of wood that we had been doing.

We succeeded with our first winter with the RMH as we dropped the amount of wood burned from 32 wheelbarrows (1.5 chords) with the old wood stove to 19.5 wheelbarrow loads (.7 Chords) with this RMH. This figure is even more impressive in that we used no supplemental natural gas heat as we did at times with the wood stove

The following photo shows the amount of wood that I had been burning on an average day up until January 19th, which is 24 pounds. The average daily use for the entire season dropped down to 22.58 pounds when the season ended in April.

The stainless steel bowl was used to haul out ashes. I usually filled it up after 2-3 burns. The homemade scraper worked great to scoop the ashes out of the burn tunnel.

To get an idea of how this RMH affected the temperature inside of our house, I will give you a summary of our experience in our coldest month of January. I took regular temperature readings throughout each day from various places on the stove as well as the temperatures both inside and outside the house, then recorded them on a spreadsheet.

During that month, the temperature in our house remained quite consistent with the temperature readings almost always from 60 to 70 degrees Fahrenheit. The only exceptions were three cold nights when the outside temperatures were minus zero and the temperature inside fell to 56F. On one of those days, the temperature outside was -19 F.

Otherwise, the low temperature was always 60F or higher, but around 67-69 degree range was normal and sometimes as high as 73F. We had 7 days of sub-zero weather in January and our average temperature inside was 67F that month and 20F outside.

Remember, this consistent temperature was achieved with no supplemental heat from other sources.

Unlike a regular wood stove, a RMH is not normally burning all day long. We typically burned ours for 1 ½ – 2 ½ hours either once or twice a day as needed. During the coldest part of January, I did have one burn that lasted 12 hours, but that was quite beyond the norm.

The temperature of the barrel would range between 350-700F on top of the barrel to generally around 200F at the bottom. The total surface area of the barrel exceeded the total surface area of the wood stove, so I would have expected that the house would have gotten warmer quicker than with the stove. However I didn’t experience that advantage, perhaps because the wood stove set was setting lower toward the floor than the RMH barrel. Just a guess. I am not certain on the reason.

One thing that impressed me was that when I loaded the wood feed at the start with smaller sticks, topped with 3-4 pine cones and a handful of straw tinder, I could often have the top of the barrel at 700F within 5 minutes of lighting it.

Partway into the year, I added a 1/3rd barrel section to the top of the original barrel. This seemed to heat up the house a little quicker, but only marginally.

The draft was quite strong and never had a problem with cold starts, though it was a little slow whenever I did not burn for several days and the temperature outside was not much cooler than inside. In those situations, I had to burn slowly at first until the heat and the draft built up. When the bench was warm and the temperature was cold out, the draft was often strong enough to put out my fire stick as I was lighting the tinder. I did not have to prime the riser with a candle that some stoves need in order to start when cold.

The experimental lid on top of the barrel is temporary, maybe. It is sitting on three bricks. Its purpose is to protect the ceiling from getting too hot after raising the height of the barrel. It has worked quite well. However, I intend to modify it for next season with the idea that it may reflect the heat more outward in the direction of the floor instead of directly down on top of the barrel. My present idea is to bevel it in the manner like is done for musical steel drums with the bevel down and held up with metal legs. This would simply sit on top of the barrel and is easily removed.

The top 1/3rd barrel section is a little discolored after using it awhile. The lower barrel never experienced this discoloration when it was the top. I don’t know what made it different. Before next season, I plan to move the smaller barrel section down to the bottom with the bigger barrel on top. The 1/3rd section will be buried in cob.

In the above photo, I stuffed rags between the bricks under the bench to stop the air flow. This was part of an experiment to see if I could get the cool air current at floor level to flow in behind the bench from the bookcase side. It seemed to have helped pull more heat to that side of the house. I need another season to fully test this theory more thoroughly.

The lid over the the wood feed is a glass pot lid. It is perfect in that it allows me to see better what is going on in the wood feed when it is partway or fully covered. This lid will serve a more important function next season with a modification that I intend on implementing. More on that in a moment.

I measured the bench temperature using a handheld infrared thermometer gun in two locations, one was on top that was covered by a blanket and the other on the front side that was uncovered. The covered portion in January averaged 120F and the front part averaged 98F. The bench was always a favorite place to sit during the winter. Nothing beats direct heat to warm up after coming in out of the cold.

The highest temperature in January for the bench on the top covered portion reached 184F once. That was tough to sit on for long periods. That happened the one day when I burned the stove for 12 hours when it was -19F outside. I believe that with the modifications that I have planned for next year, I should never have to have a 12 hour burn again.

The lowest temperature in January for the top of the bench was 80F. The front of the bench, not being covered and constantly radiating heat to the house reached a max of 148F and a low of 69F.

The temperature of the flue exhaust during January was often over 300F. This amount of heat loss indicated an area that could be improved with some modifications such as replacing the channel in the bench with one or more stratification chambers.

There are a couple of drawbacks that I encountered this first season with the RMH. I had previously cut wood to the size that would fit in the Menards wood stove. This RMH uses smaller pieces of wood in order to run efficiently and most of my wood was not split to that size. This required me to spit more wood, which wasn't a problem. However, next year, my wood will all be split to size and ready to throw in without that hassle when there is snow on the ground.

Additionally, there were a lot of knotty pieces that would have fit just fine in the wood stove that I had to split down further if I were to use them in the RMH and many these were tough to split with an ax, so I had to lay many of these aside for the wood splitter at a later time.

This RMH required me to spend more time managing the fire generally than the wood stove, which normally I could stoke and walk away for a time. The wood in the RMH burned quickly, so it did not allow me to walk away from it for extended periods. Toward the end of the season, I learned more efficient ways of managing the fire. That, along with the modifications that I have in mind for next year might reduce the time I have to spend on this task.

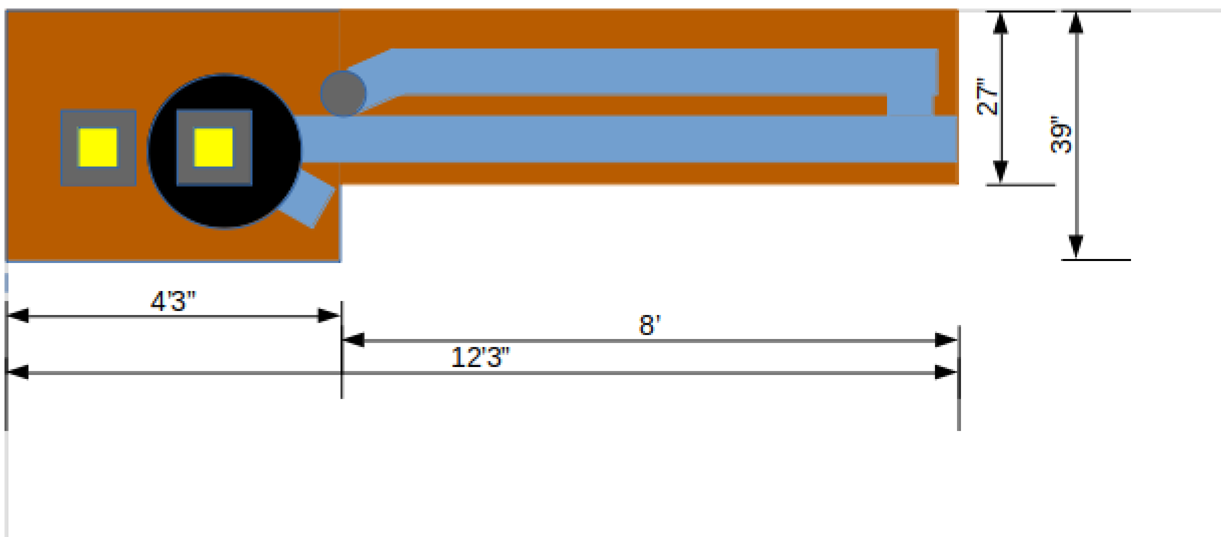
How I calculated wood usage

The way I calculated wood usage was a bit tricky because I measured it by the wheelbarrow load with my previous wood stove and by weight with the RMH. To convert my wood stove's usage to weight, I weighted several wheelbarrow loads of what I would use on average using various kinds of wood. I stack the wood on the wheelbarrow until I can't put anything else on it without it falling off.

All of my loads came in at over 175 pounds, so I used that number for all my calculations in order to keep my figures conservative. Thus, if I am off at all, the comparisons would work more in favor of the wood stove over the RMH.

Although it is a little more of a chore to weigh everything, it does appear to be a more accurate way to keep track of usage. A punky piece of wood will weigh much less than a piece of solid mulberry, but it will also not provide as much heat, so it should all equal out at the end.

I measured 21 wheelbarrow loads of wood for a chord that I have stacked a few times in past years, thus a chord of wood for my purposes would equate to 3675 pounds. I use a variety of kinds of wood, ranging in hardness from soft silver maple to mulberry, which is a realtively hard wood, so I think that this weight is pretty close to being right for what I have been burning.



- System size – 7"
- Cob mix sand to clay – 2.5:1-3:1 plus straw (Note that this is what worked best for the materials that I used. This ratio could vary depending on the clay and sand used)
- 4" gap from back of bench to wall.
- Core section height - 2'
- Bench height – 20.5"
- Bench channel - 7" + 1/2" rise over the length of the run in one direction.
- Length of horizontal channel in bench - 15'3"
- Cob layer above the channel - 5-6"
- Gap: With Initial Barrel: 2 3/4"; Added 1/3 barrel: 14 3/4"
- Burn tunnel measurements -
  - Burn tunnel - 7.25" x 6.5"
  - Length of burn tunnel - 23.25"
  - Fuel feed height – 16"
  - Riser height - 48"
  - Inside rim of Riser and wood feed 6.5" x 6.5"
  - Cross Sectional Area (CSA) for burn tunnel - 45.5 sq inches for
  - Cross Sectional Area (CSA) for riser and wood feed - 42.25 sq inches
- Length of vertical flue 18'; 12' is insulated.

General overview of this RMH build

The following pictures should give you an idea how I constructed this heater. The wood floor is plenty strong to support it with 2x12 joists 16” on center and a support beam running down the center of the room, thus giving us a 7’ span where the heater sits. This seemed like overkill, but I made it that way when rebuilt the house after I fell through the old rotten floor that was there when I bought it. I determined that will not happen again.

The CDX plywood on the wall was for the cob heat shield that I put on later. I nailed it full of roofing tacks in order to hold the cob. Initially, I made it only the height of the drum, but later took it all the way to the ceiling.

The first layer of bricks were placed so that every other row set directly on a joist. I placed resin paper under this row to protect the floor. There is a 4” gap between the wall and the back of the heater for both safety and airflow as the air circulated under the stove from the front and exited the back and up the wall.

The bricks directly under the core did get hot, but never enough to cause me to become remotely concerned with damaging the floor. These bricks were 3” above the floor and the bricks they were sitting on never seemed to get warm at all. The bricks under the bench barely got warm. On hindsight, it would have been good if I had taken some temperature readings underneath the core for verification. I will do so next year.

I put a layer of cob on top of the bricks. An area for the core was prepared which held the sand for the base.

This is the completed core. The mortar is clay slip. The firebrick is rated 3000F. I used hardened bricks for the wood feed in order to be more durable when feeding the fire. These bricks are lighter in color and were more expensive. I used 10 of these.

Mixing the cob was the most labor intensive part of the job, but it was rewarding. Here, most of the cobbing was complete. Notice the location of the clean outs for the manifold and the channel.

Improvements planned for next season.

- 1 or 2 Stratification chambers in the bench
- A stove top next to the barrel with its own stratification chamber beneath it.
- A bypass value from the stove stratification chamber to the flue.
- A beveled heat shield reflector on top of the barrel (explained earlier)
- Add two courses of firebrick to the riser
- **Cold air intake from floor level for the wood feed instead of present height**
- **Passive Air draw next to the barrel to pull the cooler air on the floor up alongside the barrel to be heated**

I will not give much explanation on the stratification chambers here other than to say that in principle with their inherent design, the hottest part of the exhaust is retained within the bench instead of exiting through the roof. There is sufficient information on the internet that explains this concept. At the time that I am writing this paper, I still have not decided on my final design with it. My preference would be to stick with cob because I simply like the feel of it.

I may add that I do plan to make the stratification chamber slope slightly higher at the opposing end of the bench from the barrel in order to encourage the heat to flow toward that end. This is not an idea that I have seen anyone suggest so far.

The stove top may utilize a 30 gallon barrel, the top of which would radiate more fast heat into the room to speed up the time it takes to heat the furnishings in the house, which should also be thought of as part of the total thermal mass. The top of this barrel is expected to be good to warm food on, perhaps even to cook on. This barrel will act as a stratification chamber that will receive the first exhaust from the manifold before being directed into the bench. I plan to build it directly in front of the vertical flue.

I may install a bypass valve from this second barrel to the flue, which may be opened when the coals are burning low toward the end of a burn. In theory, this could reduce any cooling of the bench with the less heated exhaust.

I plan to add two courses of firebrick to the riser, which would add 9” to the height, thus leaving about a 5” gap between the top of the riser and the barrel top. This would give me a riser of about 57”. I don’t know for sure if this will be a significant advantage, but I suspect that I might get a more thorough burn by doing this.

During the shoulder season when I did not burn the RMH consistently, there was a slight amount of creosol buildup in the bench channel, so there had to be times when the fire wasn’t consuming all of the fuel. The bench temperature during the shoulder season tends to be room temperature and it takes a little while to heat up the cob and the firebrick, thus the creosol would build on the cooler channel walls. Once the bench and the riser would heat up sufficiently, this buildup would always burn out.

The last two items that deal with cold air intake may be innovative on my part, being that I have not seen anyone do anything quite like this, so I will explain what I have in mind.

My object on the first one is to draw the coldest air from the floor level to feed the fire instead of drawing in the warmer air from the 2’ above the ground level where it is positioned currently.

I had a Pioneer Princess stove several years ago that had an air intake at about waist high. The air was always warm above that level when the stove was burning and cold below it. The floor was always cold. I modified the stove so that the air would draw from the floor level,. This pulled the warm air from above down to the floor. In this way, the floor actually became warmer. Keep in mind that a warm floor is also thermal mass.

I briefly experimented with a similar concept for my RMH this winter as you can see from the following picture. I made a temporary draw channel using bricks toward the wall and down toward the floor using wood slats and closing off air leaks with rags. I succeeded to draw air from the floor with this means with no noticeable change in the way that the stove burned. Doing it this way required that I have a lid over the wood feed to force the air to move through the channel. When I make this feature permanent, I expect to make the channel follow the route that I will show in the diagram at the end of this report.

The second cold air draw I am planning will be a draw channel that will run horizontally from behind the vertical flue near the floor directly to the manifold that is presently buried inside the cob, then upward next to the manifold through an oblong shape vertical cob flue. I will have to take out some cob to implement this feature and build up a cob flue that will rise to the height where the manifold meets the bottom of the barrel.

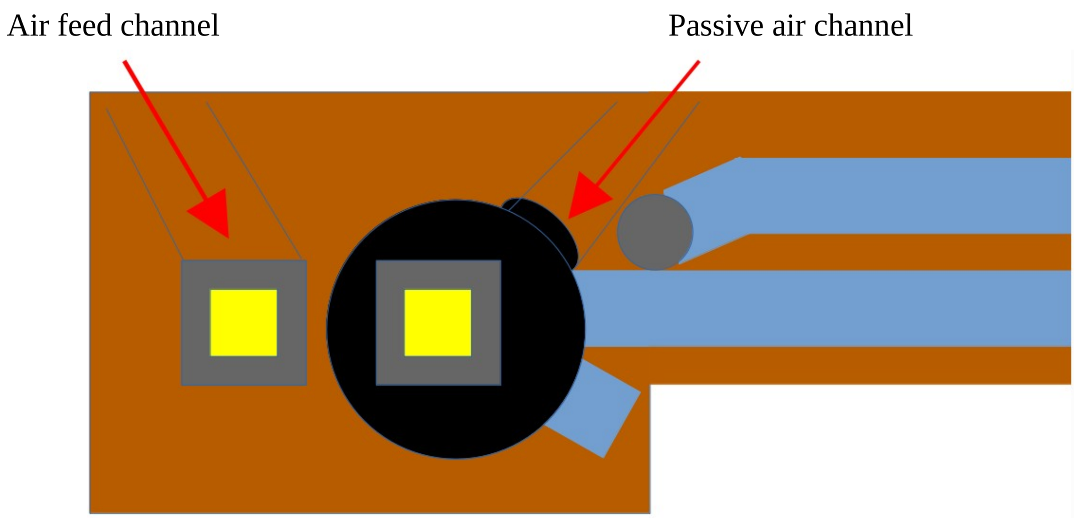
I am looking at making the channel similar in size as that used for the rest of the RMH, but flatter in shape throughout in order to more efficiently heat the air next to the manifold as well as to stay close to the floor level as I can in order to draw the coldest air.

The idea here will be that the manifold will continually heat the cold air from the floor and exhaust it alongside the barrel as long as the manifold stays warm, which will be long after the fire goes out. Even though this feature is entirely experimental and I have not seen anyone else do this, I am confident that it will work.

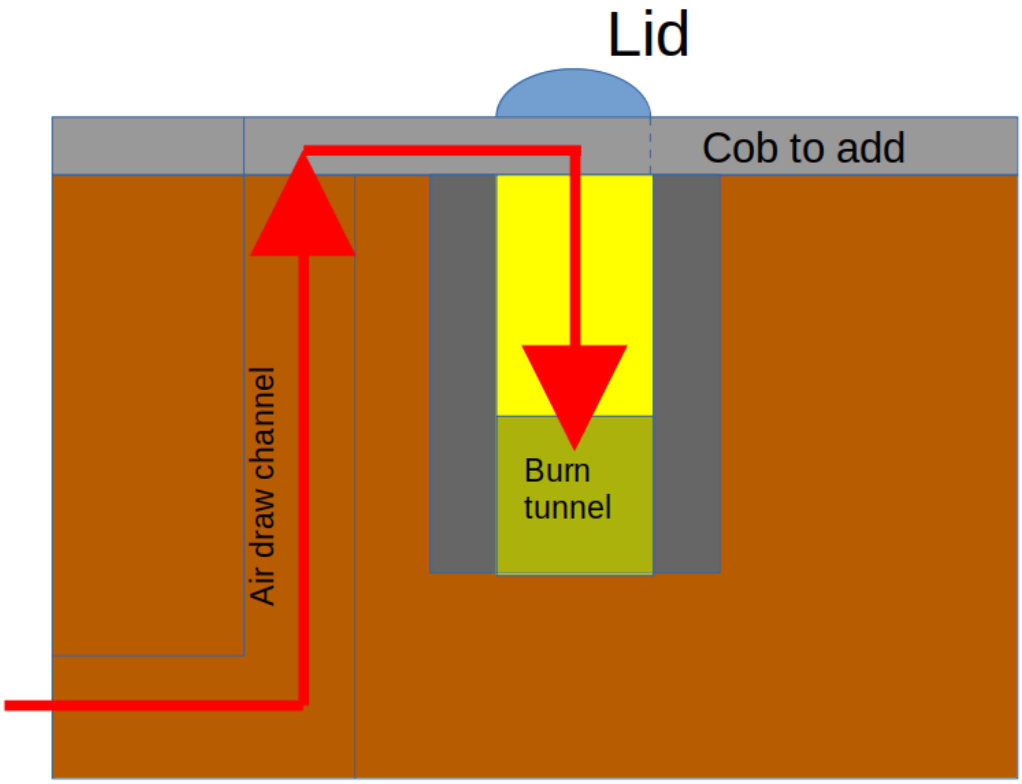
I plan to be be building all of these features into my RMH for next season.

The diagrams below shows approximately where I plan to install these two cold air intake channels marked with some elementary lines. I am wanting the channels to draw in the coldest air, which is why they appear slanted toward the corners. The air circulating at floor level from in front of the bench and underneath the core toward the back will be warmer, so I did not want to suck that air into the wood feed if I could help it.

Also, the draw channel directly behind the vertical flue happens to be right where I have a cold air draw tube coming out of wall which I installed for the previous wood stove. The cold air draw reduces how much air is pulled from under the front and back doors and cooling the floor as it flows toward the stove.



Air feed channel



Passive air channel