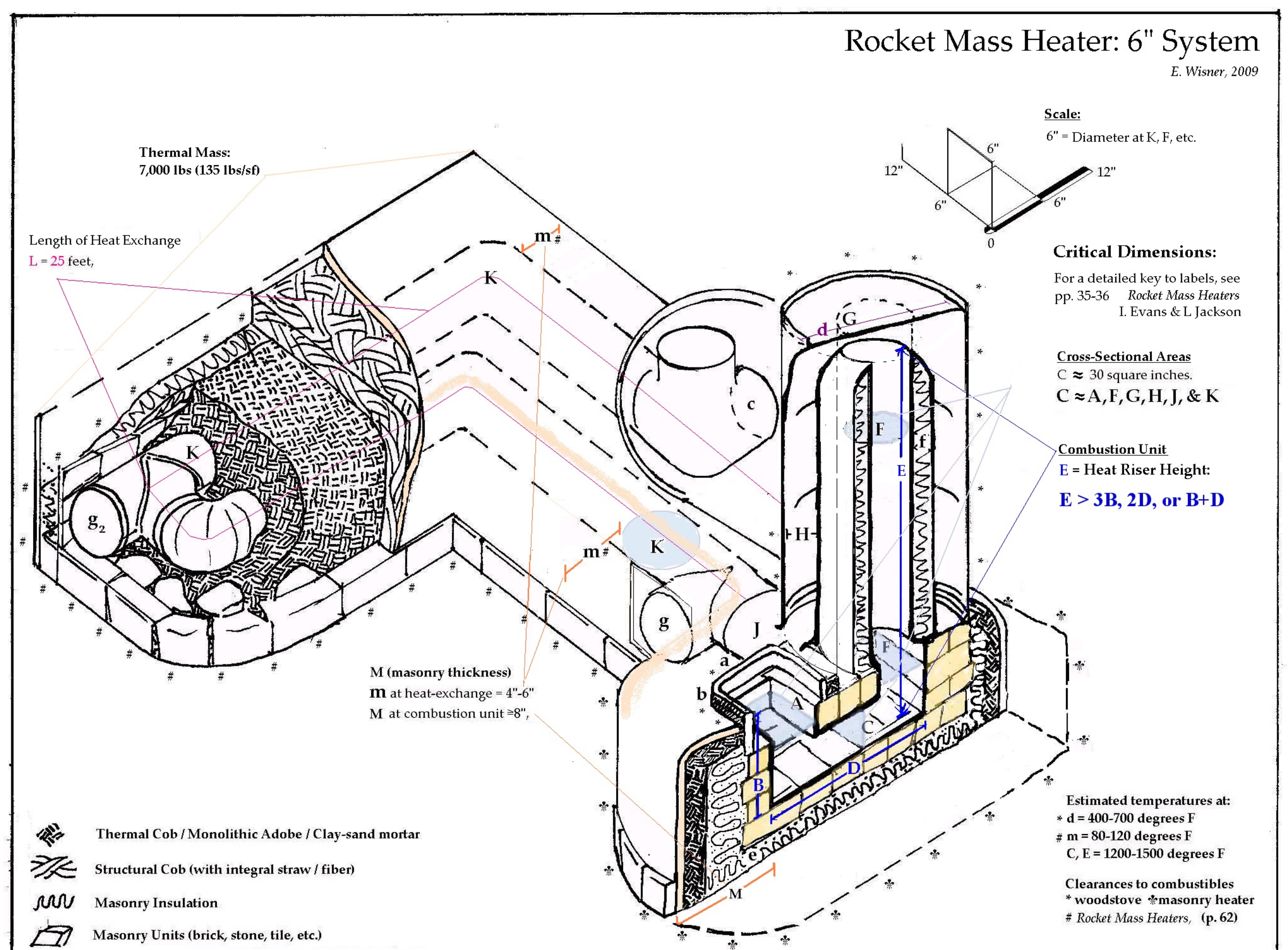
For more photos of rocket mass heater projects, and free online technical discussion, we suggest
- the forums at Permies.Com
- the book Rocket Mass Heaters, www.rocketstoves.com
- and our own website's rocket stove pages at www.ErnieAndErica.info

A complete photo-essay of this heater's building process is available online.



Rocket Mass Heater
As-Built Drawings

The Annex: 6" Diameter

duct-heated L-bench
over concrete slab floor

Ernie and Erica Wisner
http://www.ErnieAndErica.info

Materials Used:

Bench base: Concrete garden pavers and rubble - about 25-30 square feet, 4" to 5" tall; more if available for infill.

Bricks - reclaimed older building bricks (reddish, soft-fired clay, like terra cotta) - about 120 for combustion area, more if available for back of bench / insulation gap.

Perlite - about 10 cubic feet for heat riser and wall insulation

Ducting and stovepipe - all 6" interior diameter unless otherwise noted

Ducting in bench:
- about 25 feet of straight pipe - 4 sections of 5-foot length, plus 2 2-foot sections, 1-foot extension at end.
- 3 T's (6" to 6" all ways)
- 3 T caps (stovepipe)
- 5 elbows
- 6" round to 3" by 10" rectangle duct piece (cut and tabbed into brickwork, to connect ducting with barrel)

Exposed stovepipe:
- 8 foot telescoping double-walled stovepipe
- Ceiling box
- Triple-walled, insulated through-roof pipe
- 'witch's hat' and collar for roof
- roof sealant
- stainless extending 2' above anything within 10 feet
- chimney cap with screen

Barrel: 35-gallon or larger steel drum, with paint removed (ours originally held industrial-grade ascorbic acid, vitamin C)

Clay & Sand:
Desired proportions are about 10-25% true clay, 70% sand, with maybe a little bit of silt or gravel. In our Western Oregon location with its heavy clay soils we used:

Clay - up to 1 yard of local clay-rich soil, plus - 20 gallons reclaimed pottery clay (or 2 50-lb bags powdered fireclay)

Sand - 2-3 yards of local masonry sand

Straw - 1/2 bale

Plaster materials:
- chopped straw, and/or horse manure - about 3 to 5 buckets,
- concrete pigment (orange 'red ochre', about half of a 5-lb bag)
- remainder of clay and sand
- lime putty or type S lime if

Tile and details:
- Reclaimed tile - 3 10" by 10" or larger to cover cleanouts; 1 6" by 6", assorted 4" by 4"
- Ceramic chimney flue liner piece (8" square interior, cut down to 2-4" height) at fuel feed.
- One or two extra bricks to control air feed.

Heat riser:
NOTE: Original drawings show cast-in-place heat riser using metal forms and packed ceramic clay and perlite.
Other methods for heat riser may be more durable:

- 36 additional bricks,
- 2 ft x 8 ft rock wool insulation, and
- 4 ft x 4 ft wire mesh or thin metal to cover insulation

OR pre-cast 6" ID refractory insulation,

OR original method: 36" lengths
- 6" diameter steel pipe (inside liner)
- 12" diameter duct (insulation container)
- 4 cu ft perlite plus 3 gallons clay slip

Cut slots in base of outer pipe, bend inward, crimp flush with inner pipe, and use foil tape to seal a temporary flat base.
Fill with tamped perlite insulation mixture, thick enough to be self-supporting. Tab top edge likewise, cutting tabs a little extra-long to produce an angled slope.

Tools used:

Layout & Prep:
Measuring tape & yardstick, marker/pencil
Level
Plumbline (align roof & ceiling holes)
Cardboard & markers for templates
Masking tape or chalk line for marking on walls

Ducting & stovepipe:
Tinsnips or hacksaw
Crimpers or pliers
Tools for making & supporting the through-roof hole (Drywall saw, wood saw, drill, & screws)
Tight-fitting gloves
Sheet metal screws & drill for duct joints (and/or high-temperature foil tape)

Mixing earthen materials:
Shovel(s),
(optional hoe; mattock or pick)
Wheelbarrow
Tarp(s) (8' by 10', plus smaller ones, bags, or bins for staging materials)
Buckets (5 to 10 or more)
Paint stirrer (to mix clay slip with electric drill)
Screens (1/4" mesh, windowscreen)
Boots & gloves
Dust mask for perlite / powdered materials

Masonry, Mortars, and Plasters
Masonry saw (or hammer and cold chisels, or a lot of broken brick and extra mortar)
Trowel(s) (assorted sizes)
Float(s) (steel + wood or plastic)
Paintbrushes for slip / water

General parameters:

Footprint: 7 ft (27" wide) by 10ft (30" wide)
= about 35 square feet

Ducting: 6" diameter
Duct length: 25 ft,
with 7 90 degree bends =
effective drag 55 ft
(Vertical rise is additional 25 ft, double and triple-walled stovepipe; compensates for 5-10 feet of drag.)

Fuel feed: 5.5" by 5.5"
Heat riser height: 47"
Burn tunnel length: 21"
Feed tube height: 15"

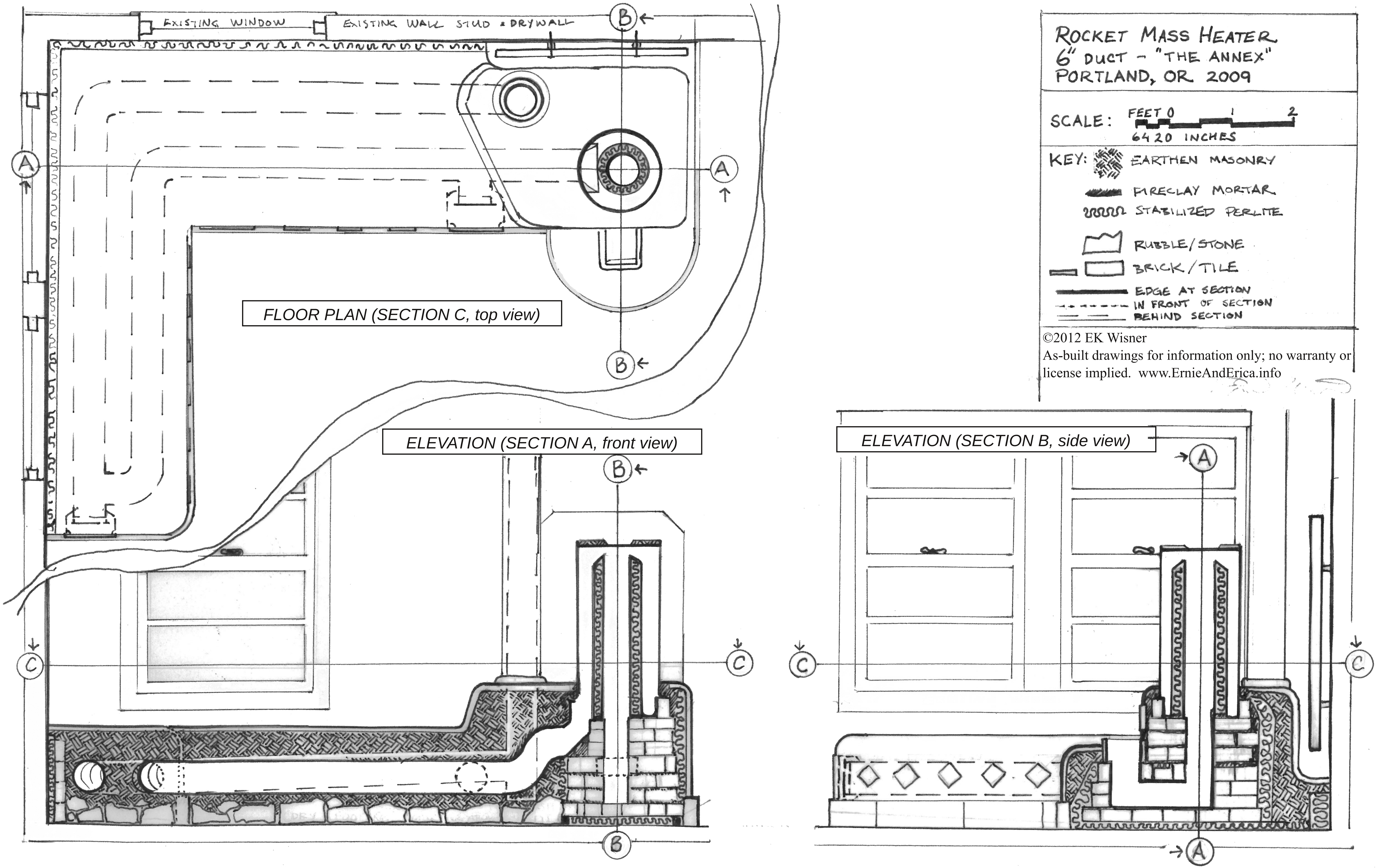
Bench volume: 60 cu. ft
(2.2 cubic meters)
Approx. weight: 5700 lbs,
dead load 125 to 240 lbs/sf

Working temperatures:
Flame path: 1200-2800 F
Barrel surface: 200-800F
Masonry surfaces: 60-90 F

Performance: Heated 900 SF cottage (with poor insulation, long wall surfaces, and no solar gain) in maritime climate (Portland, OR).

Used 1/8 to 1/4 cord of local firewood per year (Doug fir windfall, orchard trimmings, debris and building scraps).
20 lbs wood for typical winter day (30 to 40 degrees Fahrenheit). Ran about 2-4 hours per winter day, up to 6-8 hours when temperatures were unusuall low (teens F).

We used this heater for about 3 years on site. We cleaned out the fly ash about once per year, an accumulation of several inches in the bottom of the barrel. We also noticed benefits in summer heat waves: we didn't need to get the fans out of the attic for summer cooling.


ROCKET MASS HEATER
6" DUCT - "THE ANNEX"
PORTLAND, OR 2009
SCALE: FEET 0 1 2
6 4 2 0 INCHES
KEY: EARTHEN MASONRY
FIRECLAY MORTAR
STABILIZED PERLITE
RUBBLE/STONE
BRICK/TILE
EDGE AT SECTION
IN FRONT OF SECTION
BEHIND SECTION
EXISTING WINDOW
EXISTING WALL STUD + DRYWALL
FLOOR PLAN (SECTION C, top view)
ELEVATION (SECTION A, front view)
ELEVATION (SECTION B, side view)
A
B
C

<u>THE ANNEX - 6" Rocket Mass Heater:</u>
Builder's Notes

This project was originally built in Portland, Oregon, in 2009, in a small 'granny flat' apartment. It was designed as a test case for permitting, so it follows local building codes: the heat shield, clearance behind the barrel, and double-walled chimney are typical of non-certified woodstoves. A 4" gap behind the combustion chamber follows masonry heater standards. The existing 4" concrete slab is more than adequate for the weight.

<u>Design Intentions:</u>

This design is based on Moroccan hospitality rooms, where long benches double as seating and guest beds. The 18" height matches a favorite wooden bench (not shown). Pulling the wooden bench into the angle of the L creates a double guest bed.

Construction is fairly typical of Rocket Mass Heaters, as described in the book by Ianto Evans and Leslie Jackson.

To learn earthen building, we encourage you to join a workshop, private project, or read up and create a small outdoor project to try your technique and test local subsoil mixtures. The following remarks assume some familiarity with Oregon-style cob.

Finished cob, like adobe, weights about 95 pounds per cubic foot. A 4" concrete slab footing can handle dead loads equivalent to about 2-3 feet of cob height. As with any building, a good hat and a good pair of boots (roof and well-drained foundation) will ensure the long life of natural materials.

<u>Recommended Cleanouts:</u>

In designing this system for a small space, we compromised on cleanouts. Two components are removable, in lieue of cleanouts:

- Telescoping exhaust chimney: To access the ash pit below, we remove set screws and slide up lower section; then replace and re-seal. A horizontal cleanout or 'T' behind the barrel would be better.)
- Barrel: We originally set the barrel in earthen plaster, then chipped it out and re-set for maintenance (once in 3 years). This is a chore even if you enjoy earthen plasters. On later projects we have used stove gasket to seat the barrel in a shaped groove, for tidier access. We have also used part of a second, matching barrel to create a rim where the top barrel can be firmly clamped in place, using gasket and often a secondary seal of foil tape.

<u>Materials:</u>

The barrel shown is a 35-gallon, 17" diameter steel food barrel. Any similar, clean, metal barrel will do (including a 55-gallon drum, with the bench moved forward to accomodate its larger diameter). The barrel is roughly centered on the heat riser, and raised on masonry or mortar to set a 2" gap between heat riser and barrel.

Other metal components in the drawing include the heat riser and ducting. Note that all metal components are round where they intersect the masonry; this helps to alleviate stress from thermal expansion.

All ducting and stovepipe has the same interior diameter, 6 inches. All rectangular channels have this same cross-sectional area, about 30 square inches. The only exception is the interior of the barrel, where extra volume helps encourage down-draft and settle out the fly ash.

<u>Combustion Area Materials:</u>

The heat riser's internal temperatures may reach above 2500 degrees F, so high-temperature materials are essential.

<u>Heat Riser:</u> Insulated steel pipe may serve as a temporary heat riser, but extended firing eventually warps the metal and/or burns out the carbon in the steel. A more durable alternative is to build the heat riser of kiln-brick, or half-firebricks insulated with refractory felt. Another method (used in the original project) is to create cast-in-place ceramic insulation (clay-stabilized perlite, packed into temporary metal formwork), or to obtain a suitable ID pre-cast refractory insulation tube. The floor plan shows a cast-ceramic insulation cylinder, but we have described the easier-to-obtain brick version in these notes.

Once past the barrel's downdraft area, the

temperatures tend to stay below 600 F, so galvanized ducting can be used throughout.

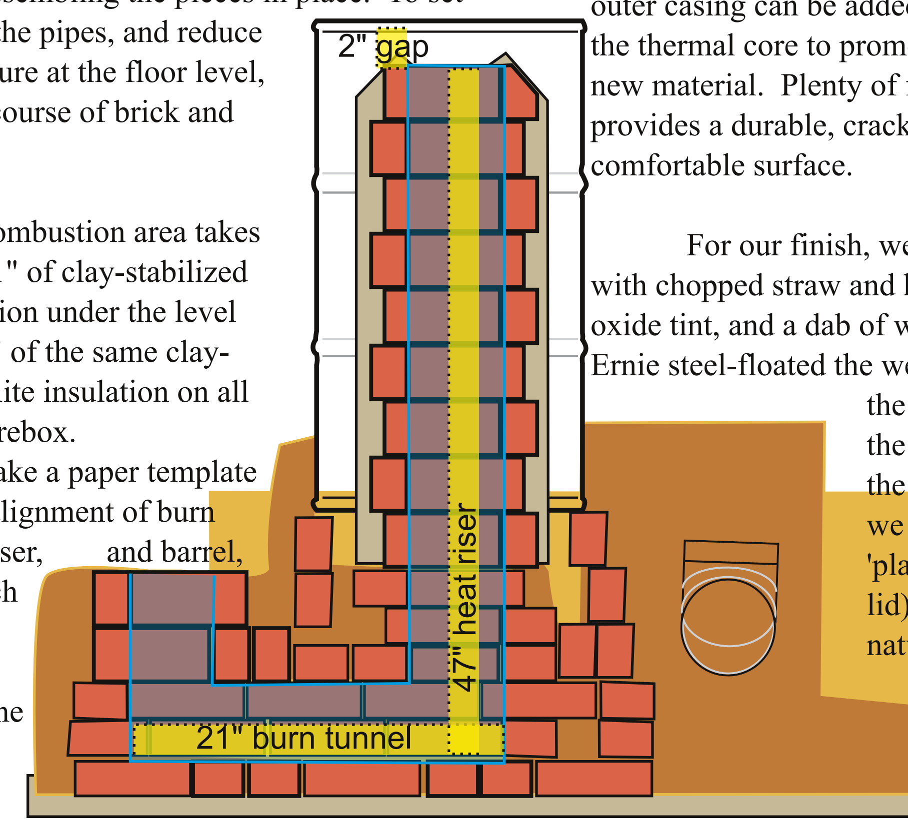
For the combustion area we used soft-fired 'common' building brick. Firebrick may be better. Avoid hard-fired facing bricks as they don't handle heat shock. **Avoid Portland cement and other lime-based products in high-heat areas** (they disintegrate).

Regardless of material, the first brick in the burn tunnel bridge may crack from heat shock and rough fuel handling. We use gaskets or removable mortar to allow for replacement.

<u>Building the Heater:</u>
We start by assembling the pieces in place. To set the height of the pipes, and reduce trapped moisture at the floor level, we lay a dry course of brick and rubble.

The combustion area takes special care: 1" of clay-stabilized perlite insulation under the level brick floor, 2" of the same clay-stabilized perlite insulation on all sides of the firebox.

We make a paper template showing the alignment of burn tunnel, heat riser, and barrel, and check each course for proper alignment. The



inside of the combustion channel is critical - the dimensions must be right, and the courses should be flush to prevent problems with loading and maintenance. See the diagrams following for brick-by-brick coursework.

After the combustion unit is laid out, and the exhaust is plumbed through the roof (follow instructions on through-roof kit, or local woodstove codes), the rest of the bench is fairly straightforward.

The bulk of the heater is a dense thermal cob, with no straw, but extra sand and rock aggregate. The ducting is set in a fine mix of this material like fireclay mortar, about 1" around al sides to double-seal the ducts. Rougher material is layered around the ducts in courses, with pieces of masonry rubble when available. Bricks or cardboard serve as forms for the 1-2" of insulation along the exterior walls (to reduce heat loss).

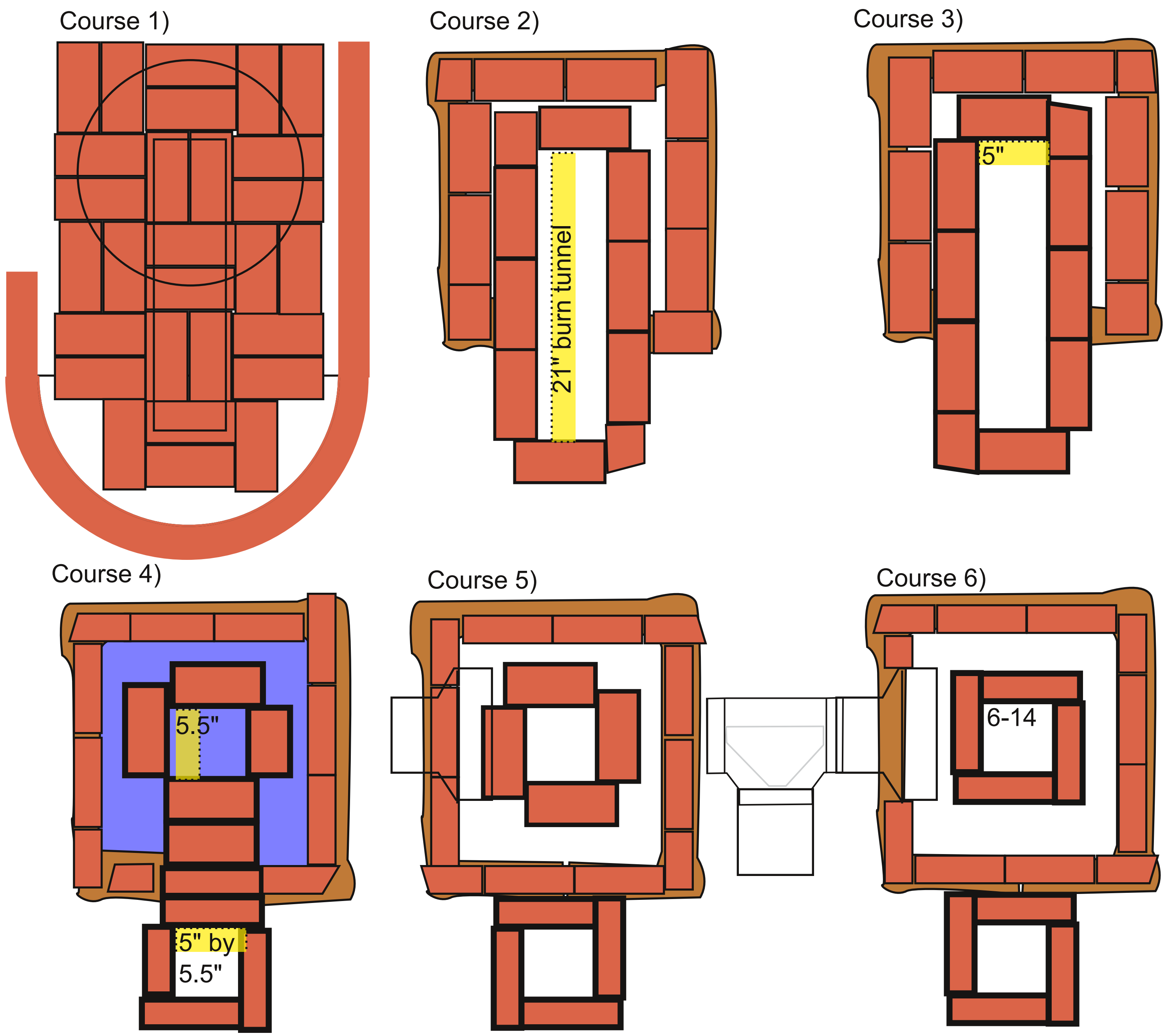
After the core is complete, it is left rough to dry for a week or more, until the surface is no longer cool to the touch. We test-fire the heater at intervals to speed drying; fans and air movement are even more effective.

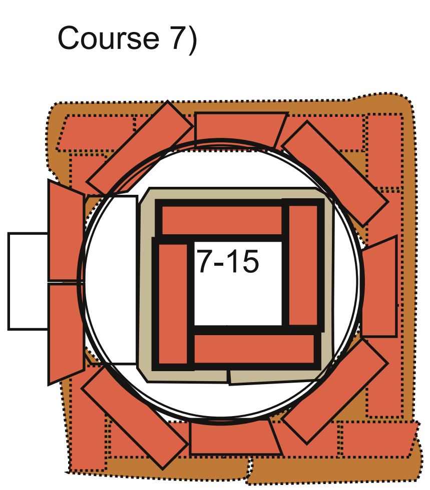
Once the heater core is thoroughly dry, the outer casing can be added. We score and clay-slip the thermal core to promote a good bond with the new material. Plenty of fiber in the natural plaster provides a durable, crack-resistant, and comfortable surface.

For our finish, we used earthen plaster, with chopped straw and horse dung fiber, iron oxide tint, and a dab of wheat paste for hardness. Ernie steel-floated the wet plaster while Erica set the decorative tiles, including the cleanout covers. Once the finish dried leather-hard, we buffed it with a wet 'plastic float' (trimmed yogurt lid) and added a polish of natural soap (less flammable, stinky, and sticky than linseed oil or beeswax).

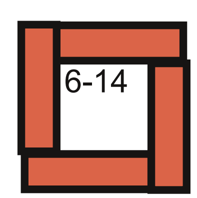
Annex 6" Rocket Mass Heater

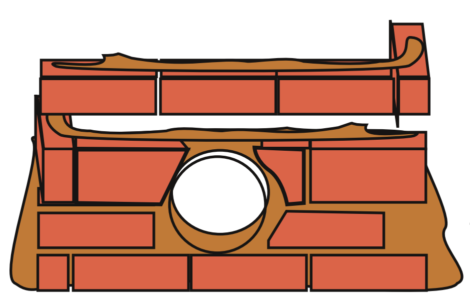
combustion unit layout





Repeat center of courses 6 & 7:
Heat riser courses continue to 47" height (measured from burn tunnel floor, course 1) alternating clockwise and counter-clockwise.





We used a special ducting piece (3x10" rectangle to 6" round), cut and tabbed into the mortar. It's just as easy to fit a round pipe:

Any breathable plaster or tile can be used on a rocket mass heater. Other breathable finishes include lime plasters, gypsum plaster, and facing brick with earthen or lime mortars.

Caution: Portland cement is largely incompatible with earthen materials. If your local jurisdiction wants to mandate the inclusion of Portland cement, concrete, rebar, or outside air feeds, please contact us for a briefing on known problems. Portland cement, for example, interferes with the clay-based bond, so instead of stronger cob, most mixtures act as really poor concrete. These materials may also introduce moisture problems.

Speaking of local jurisdictions: Our woodstove inspectors didn't know what to make of our project. The City of Portland's Alternative Technologies Advisory Committee has since approved a draft building code for rocket mass heaters, with a 1-week pre-installation approval process; this plan should pass with one substitution: firebrick in combustion areas.

If you want to get a building permit or follow existing standards elsewhere in the USA, it's worth knowing about the existing code for masonry heaters: ASTM Standard 1602-03, and Oregon's interpretive ruling 93-47. Mass stoves (>900 kg) were exempted from EPA regulation, as they're clean-burning by design and in operation, site-specific layouts, and hard to ship to testing facilities. Fireplace and woodstove regulations may not apply. RMH loads can be distributed at under 150-200 lbs/sf, fire burns hotter and cleaner, and surface/exhaust temperatures are far cooler than in woodstoves. Local standards for adobe, fireclay mortars, or general masonry may apply. Other exemptions may apply if the appliance is an antique, a building's sole source of heat, or the only way to cook.

Thank you for purchasing this document from www.ErnieAndErica.info. Please visit our site for general detail and updates, including a site planning guide. Don't hesitate to ask us questions. We love project pictures too.

Best wishes for your work and play,

Erica and Ernie Wisner

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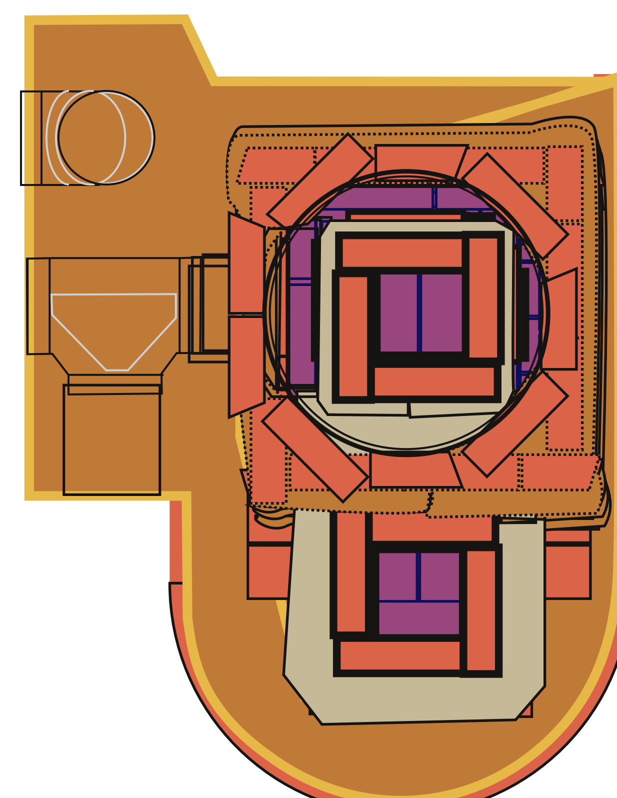
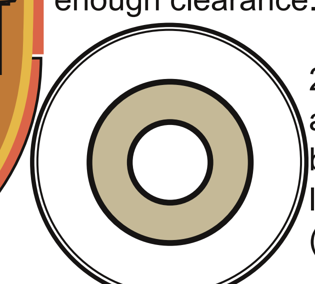


After laying bricks, we pack clay-stabilized perlite around firebox (for insulation and expansion joint.)

Metal ducting or wire mesh holds insulation around heat riser.

Cast-refractory insulation (below), or 1" of rock wool around brick (left), can fit in the small barrel and allow enough clearance.



2" of perlite, around brick, may be used with a larger barrel (shown on right).