ASPI
APPALACHIA
SCIENCE IN THE PUBLIC INTEREST
Route 5, Box 423 Livingston, KY 40445

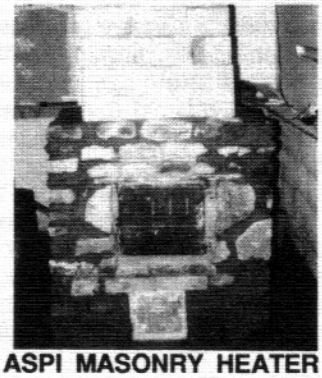
CONTRAFLOW MASONRY HEATERS/OVENS

ASPI Technical Series

INTRODUCTION

For thousands of years, fire has played an important role in northern hemisphere cultures for heat, light, and cooking. Much of the heat from an open fire is lost, either to deep sky radiation, or up a smokehole, chimney, or through air infiltration in a drafty dwelling. Huge quantities of fuel wood and large tracts of forest can be consumed without an efficient means of transferring warmth in these cases.

A vast improvement over open fires and fireplaces is the masonry heater, developed out of necessity to cope with the frigid northern winters of Finland and other northern countries. "Home is where the hearth is," and where the hearth fires are efficient and clean-burning, satisfaction and peace of mind prevail.



ASPI MASONRY HEATER

For generations, masonry wood-fired heaters have been used by northern cultures to provide an even and steady warmth. Masonry cookstoves, bake ovens, space heaters, sleeping platforms and heat-storage fireplaces all spring from this ancient tradition. Masonry heaters combine a fast, clean, fuel-efficient burn with a large passive thermal storage mass to offer an aesthetically pleasing, and physically comfortable form of heating. A modern carefully built and centrally located masonry heater fueled once or twice a day for 1-2 hours per burn can be expected to serve as the primary heat source in a new, well-insulated single family-dwelling.

The rapid combustion of the wood fuel ensures that maximum heat is generated while minimizing the emission of particulates to the atmosphere, of critical importance where air quality suffers. Thankfully, sulfur dioxide and nitrogen oxides are practically negligible in wood combustion. Masonry heating systems definitely point the way towards a renewable and efficient energy future for wood burning, with virtually no negative impacts on air quality.

ADVANTAGES

* The masonry heater is a low-cost heater if built by the owner (no export of financial resources to a distant stove manufacturer). The materials cost depends on whether one gets scrap metal and recycled brick, local native stone, or Cinva-ram earth bricks, but can be as low as $800 (mainly brick and mortar cost). Considerable savings are also realized each year by the greatly reduced volumes of firewood that are burned.

* The heater has virtually no tar, soot or creosote build-up, which means a greatly reduced risk of chimney fires.

* Wood saved per year may amount to a cord or more per average-sized building, thus conserving trees as well as saving money for the homeowner.

* The high efficiency of the heater allows for the burning of trash paper such as gummed envelopes or soiled paper which cannot normally be recycled. ASPI burns its abundant junk mail as an alternative source of fuel for its masonry heater.

* The design of the stove can include a bake oven for all types of food: Biscuits, breads, cakes, casseroles, pizzas, etc.

* The design of the stove can also include a wood cook stove for meal preparation on the range top.

* Non-renewable fuels (natural gas, propane,or nuclear- or coal-fired electricity) can be eliminated.

* The low surface temperatures of the heater are much safer for children than the extremely hot surfaces of steel manufactured wood- or coal-burning stoves.

* The masonry heater exemplifies the positive and efficient use of locally available materials -- one of the key features of any bioregionally appropriate technology.

* The heater can serve as thermal storage for passive solar designs when located near south-facing windows, clerestories or greenhouse glazing.

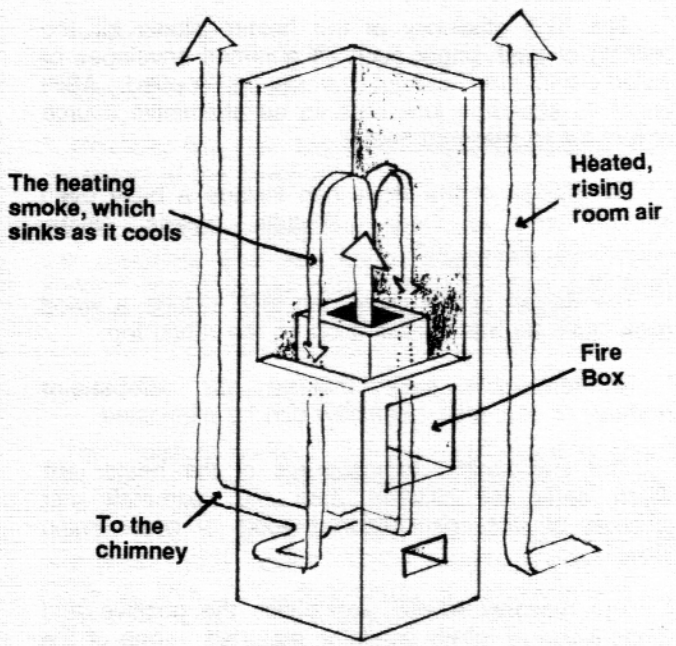
* A hot water heating system can be included into the construction of the unit if desired.

* The heaters can be extraordinarily beautiful in any setting, especially if glass doors are included in the design to allow for fire viewing.

THE CONTRAFLOW PRINCIPLE

The secret to the efficiency and clean burning of the masonry fireplaces is in the design. The firewood (split, dried hardwood 4 inches in diameter is preferred) is combusted in the firebox. Directly above the firebox is the secondary combustion chamber where gases, which contain up to two-thirds of the potential heat energy in the wood are burned. Combustion temperatures of 1650-1800 degree F. ensure a complete burn without formation of creosote, a major problem with air-tight heaters that can be a cause of dangerous chimney fires.

While masonry heaters are not well known in the United States, they have been used for centuries in Europe. The Finnish contraflow design is distinctive and unique in that it uses a secondary combustion chamber along with two vertical baffles which ensure that the heat from combustion is absorbed by the masonry of the heater and is radiated to the living space. One damper is located at the top of the secondary combustion chamber to facilitate drawing smoke when the fire is initially lit, and is closed after the wood has finished burning in order to keep any heat from escaping up the chimney.

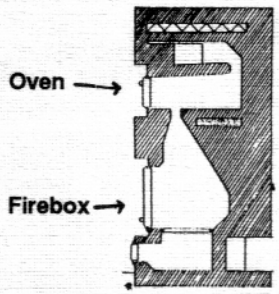


AIR CURRENTS IN A CONTRAFLOW SYSTEM

The contraflow principle is demonstrated by the downward flow of heat in the unit from the secondary combustion chamber to the flue located below the level of the firebox. This downward heat flow is contrasted to the movement of cooler currents of air on the floor in living space which, when reaching the masonry heater, begin an upward convective flow. In this way, "hot spots" immediately adjacent to the heater are eliminated, and a more even and complete heating of the entire living space is achieved.

VARIATIONS IN HEATER DESIGN

A bake oven for biscuits, breads, cakes, casseroles, pizzas, etc. can be easily included into the design of the stove. The bake oven would be located just above the firebox, with the base of the oven constructed out of firebrick for even heat distribution. Channels would surround the oven to allow the heat and gases to circulate up to the secondary combustion chamber where the gases would be consumed, and the heat would follow the downward flow ("contraflow") down the baffles to the plenum beneath the firebox and then out to the chimney flue.



MASONRY BAKE OVEN

Another practical feature that can be included into the design of the masonry heater is a wood cookstove for meal preparation on the range top. This would be constructed alongside the masonry heater with a separate firebox (and oven if desired) and stove top for cooking. Using masonry construction around the firebox and oven beneath the stove top helps to dissipate heat and eliminate any danger of injury from contact with hot surfaces. By the same account, refrigerators and freezers should be kept away from the cook stove's warmth. By integrating this feature into the overall design, yet another kitchen appliance and its space requirements could be eliminated.

An integrated loop of pipe can be installed into the heater during construction to provide for domestic hot water needs. In combination with and as a back-up for a solar hot water system no other external energy sources would be required for water heating -- yet another contribution to global resource conservation.

TOOLS

As building a masonry heater can be a complicated job, it may be best to have an experienced mason assist you. At the least, find one who is willing to give you advice if you run into problems. If you do decide to build the heater yourself here is a list of the tools you will need.

Masonry trowel
Stone hammer
Cement mixing box and hoe
Level
Pointing tool (small trowel or large spoon)
Wire brush
Whisk broom
Metal cutting equipment (possibly)

MASONRY HEATER CONSTRUCTION

* Build steel-reinforced concrete pad for foundation of heater. Foundation footings for the heater should be dug to below frostline (at least 18 inches below grade in the Central and Southern Appalachians) on undisturbed earth. A minimum of a twelve inch thick concrete pad should be poured with two grid sections of one-half inch diameter, reinforcing steel, one grid of twelve inches by twelve inches located in the first one-third of the foundation, the other grid (also 12" X 12") in the top third of the pad. The foundation should extend at least six inches beyond the perimeter of the masonry heater.

* Draw up design, including bake oven, stove, top and/or water heating apparatus, and assemble list of building materials.

* Gather building materials.

* Build the heater one brick course at a time, paying close attention to design details. A copy of the overall design with several details of variations with notes may be obtained from Paul Gallimore, Long Branch Environmental Education Center, Route 2, Box 132, Leicester, NC 28748, Price $25.00. Special attention will need to be paid to details involving the use of refractory mortars used to bond firebricks. Portland cement or pre-mixed brick cement **must not be used** on the firebox, secondary combustion chamber, or other areas in the heater where high temperatures will be generated. Also, care must be taken to properly install expansion joints between high temperature and lower temperature parts of the heater.

* Assemble metal part for dampers, door, ash clean-out, grate, etc. Some welding may be required.

* After construction of main body of heater with fire brick where necessary, apply veneer (rock, Cinva-ram earth bricks, bricks, soapstone, flagstones, etc.). The exterior of the heater will be the final and lasting tribute to the builder's care and sense of aesthetics.

* Construct a chimney for the unit using, at a minimum, an eight-by-eight inch clay chimney flue liner. A slide damper to shut off any escape of heat will be included in the construction of the chimney.

* Allow sufficient time for the masonry to cure by lighting only small "setting fires" with just ten pounds of kindling at a time. These small fires can be lit up to three times per twenty-four hour period for a week or until the heater becomes quite dry. The purpose of this process is to ensure that no cracking or thermal stressing will occur. Firewood should be stacked log cabin fashion to allow the best circulation of air for combustion.

* An additional feature that should be considered is the use of outside air for combustion. A screened, six-inch diameter pipe from the outside should be brought in to a closable floor register in front of the heater. This will avoid the problem of consuming already warmed interior air for the combustion process, and will also diminish air infiltration around doors, windows, etc. The register can be closed down when the heater is not in use to prevent unwanted infiltration.

NOTES ON HEATER PLACEMENT

Select a central location for the heater, if possible. Carefully consider the location of the heater in the proposed building. In some cases the venting and chimney arrangements limit potential choices from the beginning. Consider a location which is well ventilated, near as possible to the center of the structure being heated, where enough space for the massive heater can be found, and within reasonable access to doors where firewood can be brought in. Be sure that a clear vertical path for the chimney exists if higher stories or special roof considerations are a concern.

The major drawback with locating the heater on an outside wall is the limiting of the convective air flows in the living space and the uneven heat distribution to more distant locations in the house. No one place is perfect, but the closer to the center of the structure, the more even heat transfer to the entire space through convective air currents will be realized. People will be magnetically attracted to the heater, to work, congregate and to enjoy one another's company and the gentle warmth of the fire.

POSSIBLE DIFFICULTIES

* Insufficient knowledge of the design and construction procedure.
* Lack of sufficient space to place the heater.
* Absence of good convection current and access to outside air.
* Insecure ground and lack of a deep foundation.
* Overly rapid curing
* Use of the wrong cement products.
* Failure to install proper expansion joints which results in cracking of the heater.
* Poor chimney construction.
* Burning green wood.
* Failure to remove dust which accumulates in the building of the heater.
* Difficulty in obtaining metal heater accessories.

MATERIALS LIST

* Concrete foundation pad with reinforcing steel. (The weight of the heater will be several tons.)

* Solid fire brick (500 for 4 by 4-foot stove)

* Masonry materials for veneer -- rock, brick, Cinvaram brick, soapstone, flagstone, etc. A four-by-four-foot by eight-foot high heater will require over ninety square feet of exposed veneering material. A truck-load of rock would be required.

* Specific clay-based heater mortar and refractory mortar are required for use in all areas where fire and flue gases come in contact with masonry.

* Steel materials:

  fireplace door and hinges,
  ash box door,
  two flue dampers,
  firebox grate,
  angle iron lintels for firebox door, oven door, and oven box
  metal stove top (for cookstove option),
  fire plate domestic hot water jacket (if hot water heating option is desired).

* Mineral wool

* Gasketing (for firebox door)

* Chimney flue tiles, block and cap depending on the height of the building

The Maine Wood Heat Company can provide many of the materials that are not available locally: Albert Barden, Maine Wood Heat Company, Box 640 RFD 1, Norridgwock, Maine 04957 (207) 696-5442.

NOTES ON WOOD

The moisture content of freshly cut wood is about 50%, and if stored for a year this can drop to 25%. In a dry and ventilated storage area, moisture content can be reduced to 20% -- 15% or even 10% if stored in a warm indoor space. 20-30 pounds of dried wood (20% or less moisture content) is recommended for each firing cycle. The number of cycles depends on the severity of cold weather and building size. Generally, only one or two firings per day is needed to maintain a comfortable temperature. At ASPI the three-by -three feet, six feet high masonry heater (half the rock capacity of a standard four-by-four feet, seven foot high stove) heats adequately by use of one or occasionally two firings per day.

MAINTENANCE

* Keep heater baffle areas fairly clear of any ash material through periodic inspection and ash removal.

* Break in the heater very slowly with only small fires with small amounts of kindling to allow masonry to cure properly and to prevent any cracking at high temperatures when heater in full operation.

* Four-inch diameter split, dry (at least 20% moisture content) wood is the first choice for fuel. Wood that has been kept in the dry for at least one year after cutting will meet these requirements.

Under no conditions should Chromate-copper, arsenate (CCR) green pressure-treated wood be burned as it is extremely toxic when combusted in the home. Bronchitis, pneumonia, ear infections, blackouts, gastrointestinal ills nosebleeds, muscle cramps, dermatitis over the arms, legs and soles of the feet, and other ailments may result.

* Replaster any cracks that may develop.

* There is virtually no build-up of creosote, soot or tar materials on the heater or the chimney, but if insufficiently dried wood is burned, the chimney cap should be checked periodically.

* Keep the oven clean and free of any food particles that may have escaped baking pans.

* The areas around a wood heater can potentially accumulate dust, ashes and debris. Several suggestions may help reduce this;

1. Put down newspaper before emptying ashes;
2. When loading the firebox, use small kindling pieces kept in a portable box next to the door.
3. Ensure that the space in front of the firebox and ash removal areas is kept free of any combustible materials (including rugs).
4. Keep whisk broom and dust pan handy.

"*The user of the fireplace comes to understand that fire, like the sun is a life-sustaining and renewing force, that the real purpose of a fireplace is to renew the energy of those who gather around it.*"

from **FINNISH FIREPLACES: The Hearth of the Home**, Albert Barden - Heikki Hyytiänen

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PROJECT DIRECTOR: Al Fritsch **EDITOR: Robyn Arnold** **TECHNICAL EDITOR: Paul Gallimore**