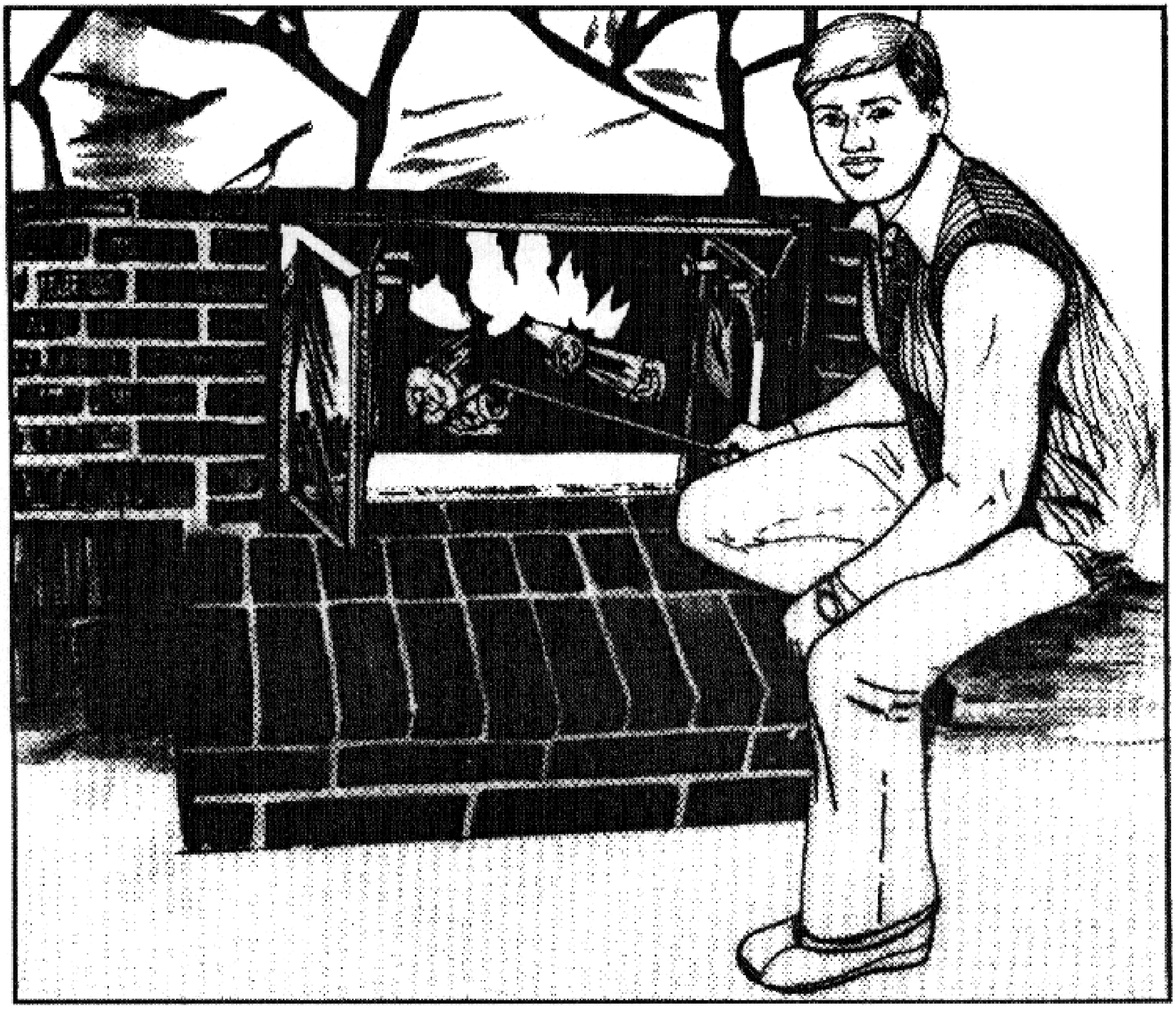
THE RUSSIAN FIREPLACE



Procedures For Constructing A High Efficiency

Masonry Fireplace

Introduction

The "High Efficiency Masonry Fireplace" is a hybrid design. It incorporates the best qualities of the Finnish or Russian woodburning furnace, which has been used in Europe for centuries, and the typical American open fireplace. The primary difference between this design and the traditional Finnish or Russian design is that this unit has an appearance similar to that of a conventional fireplace and is adaptable to most applications where open face fireplaces are now used.

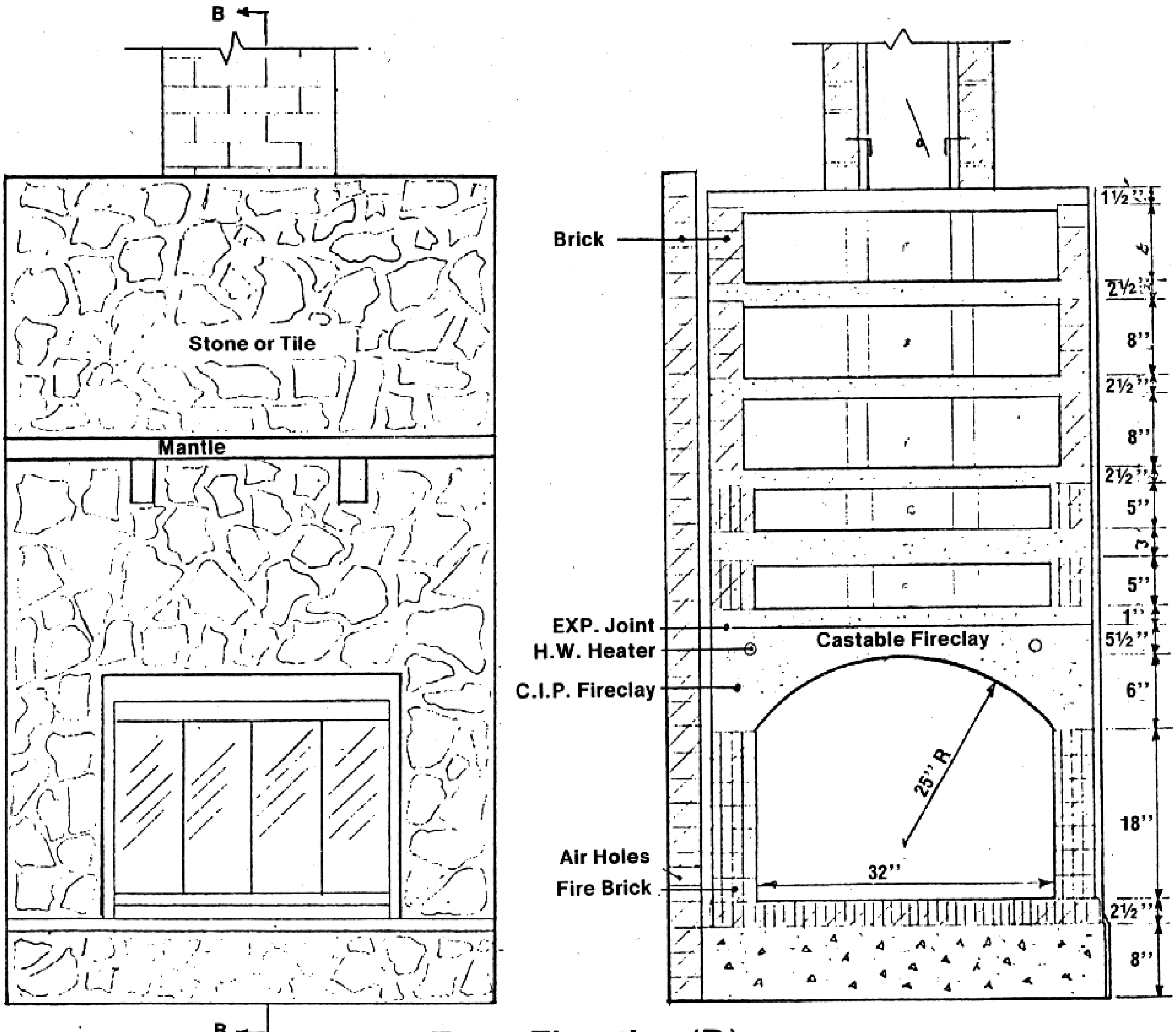
A Russian fireplace was constructed by Building Construction classes at the Beatrice campus of Southeast Community College in 1980. The work was done under contract to the Nebraska Energy Office. In 1981, that contract was extended to provide for construction of another unit, similar in function but more aesthetically pleasing, and presumably more easily marketable. Because of the emphasis on commercialization, this second unit was constructed by area contractors in a hands-on workshop.

This report provides information on the construction, operation, testing and analysis of this "High Efficiency Masonry Fireplace." Blank pages are provided at the end of the report for notes so this can be used as a "working" document.

Principles

The "High Efficiency Masonry Fireplace" achieves impressive conversion efficiencies by burning fuel slowly and keeping the products of combustion within the unit for an extended time to allow maximum heat transfer to the heated space, minimizing flue losses to the atmosphere. The slow burn results from the nearly air-tight construction of the unit. A series of horizontal baffles above the firebox has the effect of increasing the length of the flue inside the building, which increases the surface area for heat transfer from the flue gases to the masonry of the unit.

High Efficiency Masonry Fireplace



Front Elevation (D)

CONSTRUCTION

Foundation

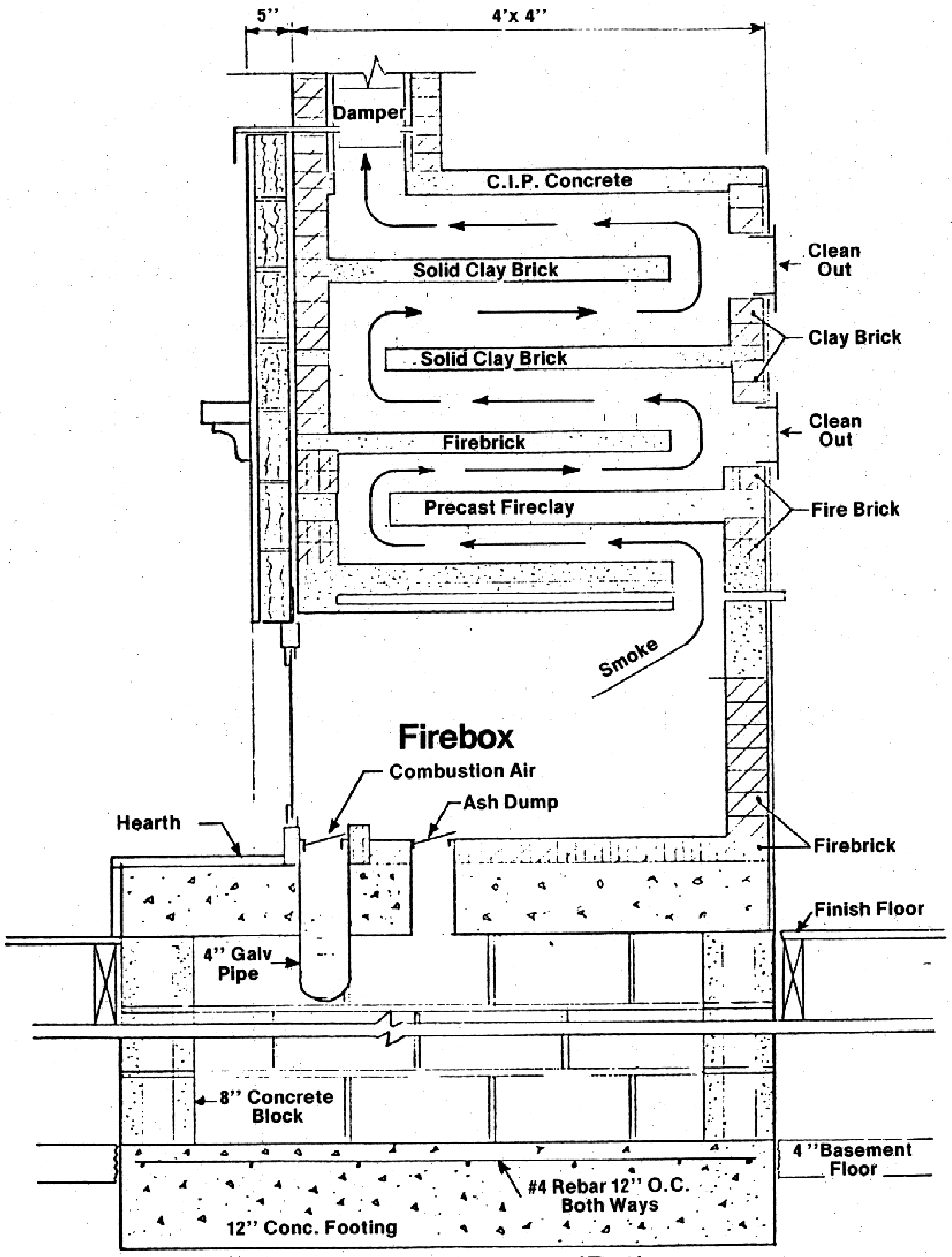
Two types of situations should be considered when discussing foundations for this type of fireplace:

1. installation in the basement of a conventional house or on the main floor of a slab-on-grade-type structure.
2. installation on the main floor of a structure built over a crawl space or basement.

When building on a concrete slab, it is advisable to remove the existing concrete floor and replace it with a 12'' thick concrete footing reinforced with ½'' reinforcing steel on 12'' centers. The horizontal dimensions of this footing should be equal to the external dimensions of the finished unit, including facing material and hearth.

When the unit is to be installed in a building with a basement or crawl space, it is recommended that a footing equal to the one above be poured at grade level and a concrete block or poured concrete wall foundation be installed with an 8'' thick (minimum) reinforced cap poured flush with the top of the finish floor. If a raised hearth is desired, this cap can be elevated to the desired height, leaving a brick ledge at finish floor level to accommodate decorative skin. See D-1 for more information.

High Efficiency Masonry Fireplace



Longitudinal Section (D-1)

Firebox

The firebox floor and walls are of firebrick and the top is made of poured-in-place castable fireclay. The floor is laid over a ¼" to 3/8" bed of masonry mortar made with portland cement, and the bricks are cemented together with fireclay. The floor extends to the outer edge of the walls (width = glass door opening width plus 9" in most cases). When outside combustion air is ducted in, one row of firebricks are set on edge to form a ledge to prevent ashes from falling into the ductwork (see D-1). This row extends only across the inside of the firebox, from wall to wall. Then the firebox sidewalls and backwall are laid up to the height of the glass doors with firebrick and the inside of these walls is coated with fireclay to prevent any air leakage.

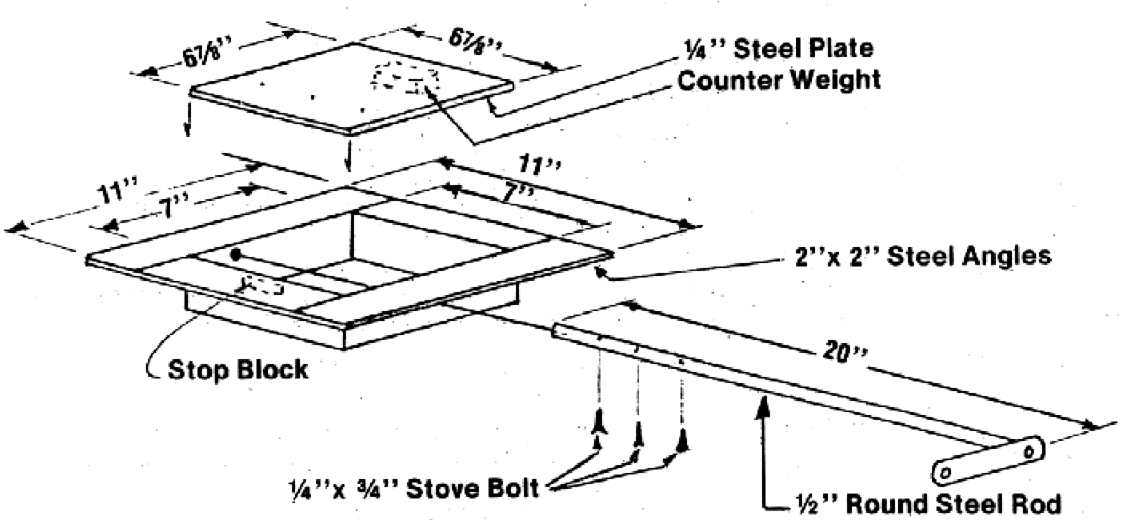
At this point the structure should be allowed to cure for at least an hour. The time can be spent building the arched soffit form and the side forms for the castable fireclay firebox top. The soffit form, which supports the castable fireclay while it hardens, can be built of ¾" plywood bows covered with thin plywood or hardboard. The form should be slightly narrower than the inside dimensions of the firebox walls to simplify later removal. It is supported on wooden legs, concrete block, or any other material that can be removed through the front of the firebox. The side and end forms can be built of whatever materials are available. Half-inch plywood over a 2 x 4 frame works fine. These should be built in full form sections so they can also be used to form the top slab of the baffle structure.

When the soffit and side forms are in place, they should be covered with plastic sheeting. Castable fireclay has a very high hydration rate and must be covered to prevent excessive evaporation, which weakens the finished product. Before pouring the castable, the stainless steel reinforcement and optional hot water tubing are added. All metal used for reinforcement of the castable fireclay must be stainless steel because its coefficient of expansion is approximately the same as that of castable fireclay. Reinforcing should be 1/8" stainless steel rod hooked at the ends, laid across the castable slab on 6" centers. When all forms and reinforcements are in place, the castable fireclay is mixed. Placing should be as rapid as possible to prevent cold joints between batches. The finished slab is covered with plastic, to minimize evaporation, and left to cure for at least twelve hours before further construction.

Smoke Chamber/Baffles

The next construction step is building the baffle system, which absorbs most of the heat from the combustion gases—heat that is lost to the atmosphere in conventional units.

Because the first two baffles through which the smoke travels must withstand temperatures in excess of 1000°F, these chambers must be constructed of fireclay materials. This can be accomplished in two ways. One method is to precast slabs of fireclay (see D-3), which are then laid in place to form the horizontal baffle. The other is to lay-in a baffle of fire bricks, supported at the joints by firebrick on the edge. Either of these methods can be used for both the first and second baffles, but the firebrick shelf is less expensive in terms of material.



Rotating Damper Assembly (D-2)

To build the first baffle chamber, two courses of firebrick are laid around the perimeter of the castable firebox top, forming the walls of the chamber, and a third course of firebrick is laid across the rear wall only. Next, four rows of firebrick, set on edge, are laid from front to back to support the joints in the baffle shelf. The firebrick shelf is laid across these supports, from back to front, with a 9" gap left at the front to allow the smoke to rise to the next level. That chamber is finished by completing the third course of firebrick around the front. The second chamber is similar, except that the shelf begins at the front (with the front joints supported by bricks set vertically from the bottom of the first chamber) and the smoke gap is at the rear.

Because of the reduced temperatures experienced in the third, fourth, and fifth chambers, clay brick has satisfactory heat resistance. It is, therefore, more economical to use clay brick for these levels. However, potter's clay is added, in a ratio of one part clay to ten parts portland cement, to the mortar mix to improve the mortar's heat resistance.

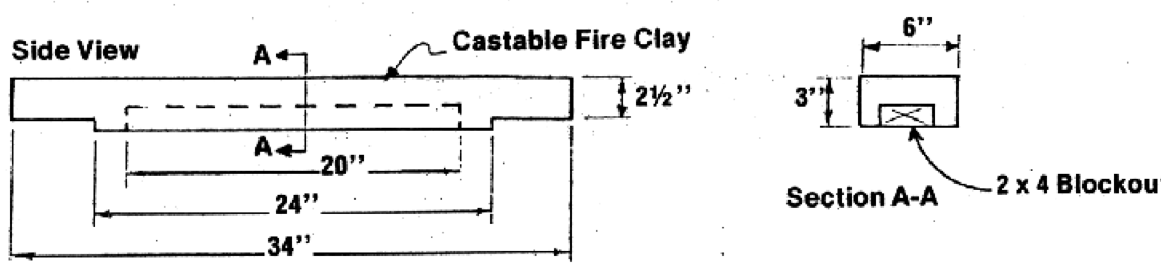
Chambers three and four are built identically, with a perimeter of three courses of solid brick and four rows of brick on edge to support each shelf. Each shelf consists of solid brick laid flat across the chamber. The only difference is that the smoke opening to the next higher level is at the front of the unit for chamber three and at the rear of chamber four.

The walls of the fifth chamber are constructed in the same manner as the others, but with only two rows of brick on edge to support the poured concrete slab, which forms the top of the unit. A hardboard soffit form is then laid over the walls and support piers. The form has 1'' holes at 12'' centers over the center piers to maintain a solid support for the slab in the event that the hardboard eventually burns away. The side forms previously used to pour the firebox are then clamped around the unit and a 9'' x 9'' block-out is made near the front to form the outlet to the chimney. The slab is then poured onto the unit using a concrete mixture with non-silicous aggregate (limestone or brick grog).

Damper and Chimney

Allow overnight curing before beginning the chimney construction.

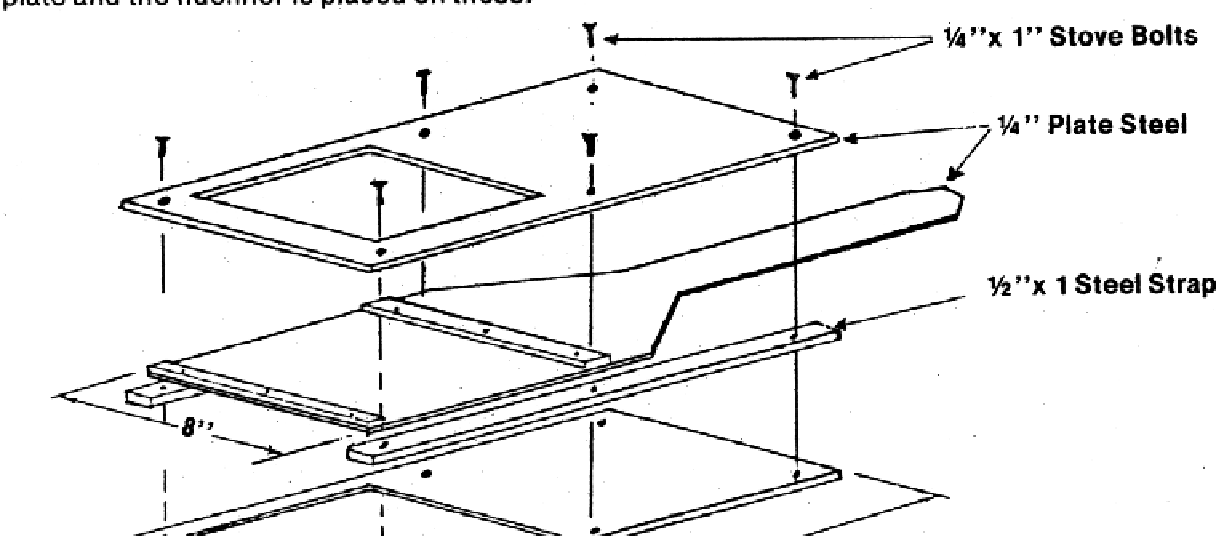
When using the rotating-type damper of figure D-2, first lay one course of firebrick around the opening in the top slab to support the damper flange. (One of these bricks must have a grove sawed across the top to accept the damper rod). The damper is then set in fireclay with the steel angle extending down inside the firebrick. Firebrick are laid over the damper, up to a level which is flush with the top of the damper panel, and then corbelled into a 7¼'' x 7¼'' opening on which the 8'' x 8'' flueliner rests.



Precast Baffle Slabs (D-3)

If the sliding-type damper is used (as in figure D-4), the damper is simply set on the fireplace slab in a bed of fireclay. Then 1/8'' shims are placed around the damper plate and the flueliner is placed on these.

In either case, the flueliner is encased in brick or concrete block and the balance of the chimney is completed in the same manner as any all-fuel flue.



Sliding Damper Assembly (D-4)

Veneer Finish

To this point all work described has been the construction of the firebox and smoke chamber. This is the heart of the unit but it is not at all attractive; most people find it necessary to veneer the unit.

A brick veneer works well, as long as a clear air space is left between the unit and the veneer. The unit must have room to expand and if it doesn't have sufficient clearance it will crack the veneer. Experience indicates that ¼'' clearance is sufficient but ½'' works better because it allows room to remove excess mortar from the space. Veneer may be tied to the smoke chamber with corrugated ties, but only in the top two baffle areas; the airspace must be kept clear to permit independent movement of the fireplace core.

Stone veneering with 4'' thick material can be used, following the same procedure as for brick. Thin stone or imitation stone works well when applied over a 4'' concrete block backing. There must be a space between the concrete block or stone and the core—the same as with brick veneering.

Ceramic tile and plaster applied directly to the firebox core have been tried but without success. Both materials cracked within a month of operation and separated from the unit. Either of these materials could, however, be applied over a concrete block backing, as long as the expansion space between the core and the concrete block is maintained.

Curing

Although not strictly a part of the construction procedure, curing must be discussed to protect the owners' investment in this unit. Because of the large volume of cement materials incorporated into this unit it is necessary to allow the unit to cure for at least 60 days before any significant use. Curing time may be shortened by pushing dry air through the unit with a fan.

OPERATION

1. Build the fire in the unit with the damper fully open.
2. Close the doors immediately and decrease the draft until the materials burn with a lazy rolling flame.
3. If the intake air control will not accomplish this, close the damper partially, 10 to 15 percent at a time, until the flame settles down. Be careful not to close it too far, which causes smoke to enter the living space.
4. When all fuel materials are reduced to embers, close the damper as much as possible. (Often it can be closed totally at this point).
5. Leave the doors and damper closed until the next loading and firing.

OBSERVATIONS

Efficiency

The combustion efficiency of this unit was calculated according to the formula:

efficiency = 100 - losses (as percentage of fuel input).

The losses were estimated by measuring the flowrate of the exhaust gases and their temperature above room temperature, averaged over the burn time. This yielded an efficiency of about 90%, slightly less than the 1980 vertical baffle unit. Two factors which might account for this are (1) the glass firebox doors which did not seal as well as the solid metal door on the 1980 unit, and (2) the horizontal baffling which allowed a slightly increased draft on the fire.

Water Heating

This horizontal baffle unit included a single loop of stainless steel pipe, cast in the fireclay top of the firebox, which was used to heat water in a 35 gallon tank mounted behind the unit. Natural circulation through the unit raised the water temperature from ambient to 120°F in about two hours. Faster water heating could be accomplished by increasing the length of the heating loop and moving that loop to one of the upper three baffle chambers. The incorporation of the water heating loop necessitates special safety considerations. Temperatures in the loop exceeded 400°F at times, which would produce steam within the unit if the water circulation was restricted. A backwater valve and pressure release valve should be provided whenever the water-heating accessory is included in the unit.

Creosote Cleanout

The combustion of wood drives off vapors that condense on cooler surfaces of the chimney in thin films. Each successive use deposits additional layers of this creosote. In time, these deposits can interfere with proper smokeflow and, if ignited, are the cause of chimney fires. Therefore, chimneys must be cleaned occasionally to remove these deposits before they cause problems. After a year of use, the 1981 unit showed no appreciable creosote buildup in the back of the firebox or the first two baffle chambers. This is probably due to the high temperatures in these areas during the first part of the burn cycle. The upper, cooler baffle chambers, and the chimney had thin creosote films, but these did not require cleaning after one year. When cleaning does become necessary, the chimney can be cleaned by conventional methods, but the upper baffles require special cleanout doors. Two cleanouts were included in this unit, giving access to four baffle chambers. The cleanouts did not seal completely, which allowed some smoke to escape when the damper was closed too soon and decreased the draft slightly. Installation of a heat resistant gasket or sealing the cleanout with refractory cement should solve that problem.

PROPOSED DESIGN CHANGES

There are three changes which are recommended for future "High Efficiency Masonry Fireplaces" built according to these plans. The unit works well as constructed, but these changes would eliminate some of the small problems uncovered during testing.

1. Relocate the firebox door assembly. In the 1981 unit, the glass firebox door assembly was attached directly to the firebox core. The proximity to the fire made the doors too hot to handle, and caused the metal frame to expand, jamming the doors. It is suggested that the door assembly be attached to the veneer instead, and then the veneer sealed to the firebox core with fire-resistant ceramic insulation around the front opening.
2. Increase smoke dome depth. The smoke dome is the space at the top of the firebox, above the level of the door opening. When starting a fire, some smoke always escaped through the door opening before the doors could be closed. Adding another course of fireback to the firebox walls would probably solve this problem.
3. Use common, rock aggregate concrete for the top slab. The temperatures encountered at this level are low enough that heat will not contribute to slab deterioration. It is also believed that a good quality clay brick could probably be substituted for firebrick in the baffle chambers (but **not** in the firebox). Fireclay mortar should still be used for the lower baffle chambers though, as portland cement mortar will not resist the heat. These changes will reduce the cost of the unit slightly.

MATERIAL LIST

QTY	DESCRIPTION	WT. EACH	WT. TOTAL
360	Firebrick	10#	3600#
800	Solid Brick	5#	4000#
2	8 X 8 Flue Liner	40#	80#
1	3/16" Fireplace Door	40#	40#
1	Chimney Damper	10#	10#
2	Cleanout Doors	4#	8#
10	Bags Portland Cement	94#	940#
½	Cu. Yd. Masonary Sand	1000#	1000#
2	Bags Kwik Clay or Fire Clay	25#	50#
13	Bags Castable Fire Clay	100#	1300#
4	50# Buckets Sair Set Fireclay	50#	200#
20	Sq. ft. Ceramic Tile	3#	60#
3	Units Catapoxy	30#	90#
	TOTALS		11378#

For More Information Contact:
Energy Extension Division
Nebraska Energy Office
Box 95085
Lincoln, NE 68509
Phone (402) 471-2867

nebraska energy office
Help Conserve the Good Life of Nebraska

A ALTERNATES
B BOOST
C CONSERVATION

Published by the Nebraska Energy Office with Federal Funds under P.L. 95-39.