Building an Efficient Fireplace

A variation of the Rumford design reflects heat into the room rather than letting it disappear up the chimney

by Richard T. Kreh Sr.

A couple of years back, my good friend Nick called to tell me that he'd bought a 40-acre tract of land in southern Pennsylvania. I wondered how this purchase would involve me, and the answer came quickly. Nick planned to build a cabin overlooking the valley, and the centerpiece of the cabin would be a large stone fireplace. Having built hundreds of fireplaces as a mason, I was the right friend to call.

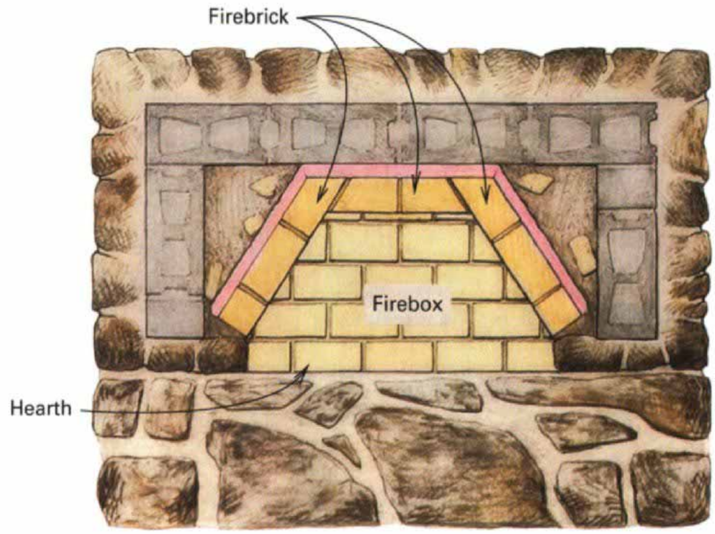
Finding stone wasn't a problem. The mountainside lot had many old stone fences and loose rock strewn everywhere. Nick, however, wanted this stone fireplace not just for aesthetic reasons but also for heating the cabin. After discussing the options, we decided that our best bet was a Rumford-style fireplace, efficient due to its wide, high, shallow firebox (photo above).

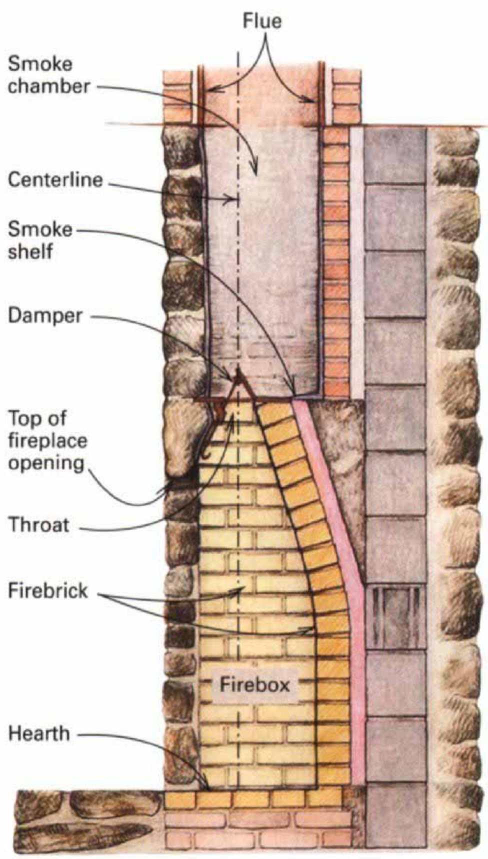
Rumford fireplaces radiate heat—Count Rumford was a talented inventor who fled the colonies to England in 1776 because he was a

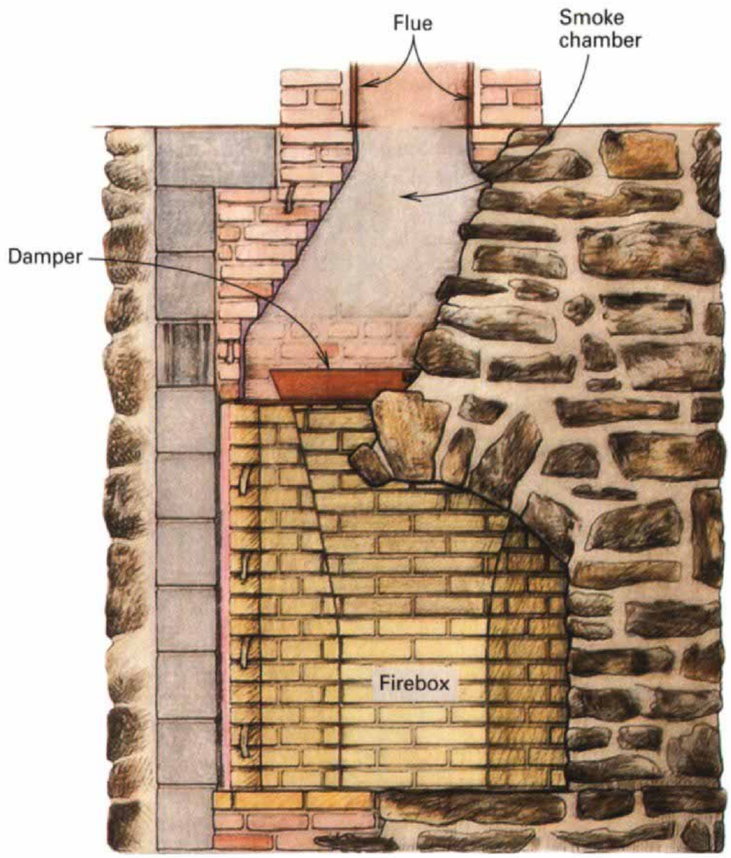
Photo this page: Roe A. Osborn

Proportions for an efficient fireplace

- *The width of the firebox at the back and the depth of the firebox should be equal.*
- *The height and width of the vertical portion of the firebox back should be the same.*
- *The area of the fireplace opening (height times width) cannot exceed W times the flue opening.*
- *The height and width of the fireplace opening should be two to three times the depth of the firebox.*
- *The height of the opening should not be greater than the width.*
- *The throat should be 3 in. to 4 in. wide.*
- *The centerline of the throat should line up with the centerline of the hearth.*
- *The smoke shelf should be at least 4 in. wide.*
- *The height of the throat should be at least 12 in.*
- *A flat plate damper should be used at the throat.*







Drawing and formula adapted from Brick Institute of America

Loyalist and supported the monarchy. Rumford was fascinated with fireplaces and chimneys. He experimented with the principles of fireplace design and construction, and he wrote a number of essays and opinions on the faulty fireplaces he observed. He built a reputation in England by repairing hundreds of faulty fireplaces.

In almost every case, Rumford discovered that the throat area (drawing above) of the fireplace was too large; throats tended to be large because there had to be enough room for a chimney sweep to climb through to clean the chimney. He discovered that a large throat made a fireplace burn less efficiently.

In his study of fireplaces, Rumford also found that the most beneficial heat emitted from a fire place is radiant heat, which is heat reflected into the room from the back and sides of the firebox. To maximize the effect of radiant heat, Rumford designed a fireplace with a tall, wide opening and a shallow firebox with widely an-

Drawings: Christopher Clapp

A concrete-block shell is laid up first. The first masonry that is installed is rough concrete block. The stone veneer will be attached to the outside of the shell while the firebox is built inside.

Angled firebox walls are sketched on the hearth. One key to a successful Rumford fireplace is the angled sidewalls of the firebox, which are laid out here on top of the firebrick hearth.

gled sides to radiate as much heat as possible. Rumford also built his fireboxes out of a smooth, fireproof material, such as brick, to promote the smooth flow of air and to reflect heat instead of stone, which has a rough surface that inhibits airflow and absorbs heat.

Getting the proportions right—As I began the plans for Nick's fireplace, I turned to Vrest Orion's book *The Forgotten Art of Building a Good Fireplace* (Yankee Inc., Dublin, N. H. 03444; 1974), one of the best books on Rumford-fireplace design and construction. In this book Orton outlines the details and proportions needed to build a successful Rumford fireplace.

I should point out that the design Orton describes in his book is actually an adaptation of Count Rumford's original historic design. Rumford's original design featured a firebox with a straight back and rounded breastwork, or front inside surface of the throat. Orton's variation, which is accepted by the Brick Institute of America in its publication *Technical Note on Brick Construction, 19C revised* (Brick Institute of America, 1988; 703-620-0010; $1) as the recommended Rumford design, incorporates a slight angle to the top half of the firebox back to increase the amount of radiated heat. Precast-masonry parts are available that form the rounded breast, but I decided against this option because I wished to build the fireplace of masonry.

According to Orton's formula (drawing p. 67), the width and height of the firebox opening can be up to three times the depth of the firebox. The back wall of the firebox should rise vertically from the hearth 16 in. to 20 in. and then slant or roll forward gently and evenly to form the smoke shelf at the top of the firebox. The damper should be approximately 4 in. deep with a smoke-shelf depth of at least 4 in., and the centerline of the throat and damper should align vertically with the center of the hearth. An-

The back wall of the firebox tips forward. To enhance the radiant properties of the fireplace, the top of the back wall of the firebox is rolled forward slightly.

other key factor in the optimum performance of the fireplace is making sure the throat and smoke-chamber areas are uniformly smooth and corbeled evenly with brick up to the point where the flue lining is set in place.

Roughing in the fireplace—Nick had seen to it that the proper footing and foundation had been built, so the first step for me was laying out the fireplace on the floor using the rough measurements in the Brick Institute's tables. We based our layout on a fireplace with a finished opening 40 in. wide by 40 in. high. Because the cabin was not airtight, we decided not to incorporate an outside air source into the fireplace.

The unfinished concrete-block shell went in first, allowing a 7-in. setback from the outside perimeter for the future stone veneer (photo top left, facing page). I embedded corrugated-metal wall ties in the mortar joints between every other course of block around the outside perimeter of the chimney to tie stone to block work.

I used the same mortar mix for all phases of the fireplace construction, including the block work, the firebrick and the stonework (some masons prefer a special refractory mortar for firebrick). The mortar mix I used is type N, consisting of 1 part type-1 portland cement, 1 part mason's hydrated lime and 6 parts sand with clean water added to get the desired stiffness.

The lime in the mix increases the mortar's ability to bond to the stone. At the same time, the lime decreases shrinkage of the mortar while imparting a nice light-gray color to the cured mortar. I recommend using only washed sand from your local building-supply dealer because of its uniform texture and because it gives the mortar a uniform color when it cures.

The firebox is laid out on top of the hearth—Nick wanted the hearth raised 8 in. above the finished floor. So I attached a guideline to the ends of the rough block at that height and laid two courses of rough brick and the outside course of hearth firebrick up to the line.

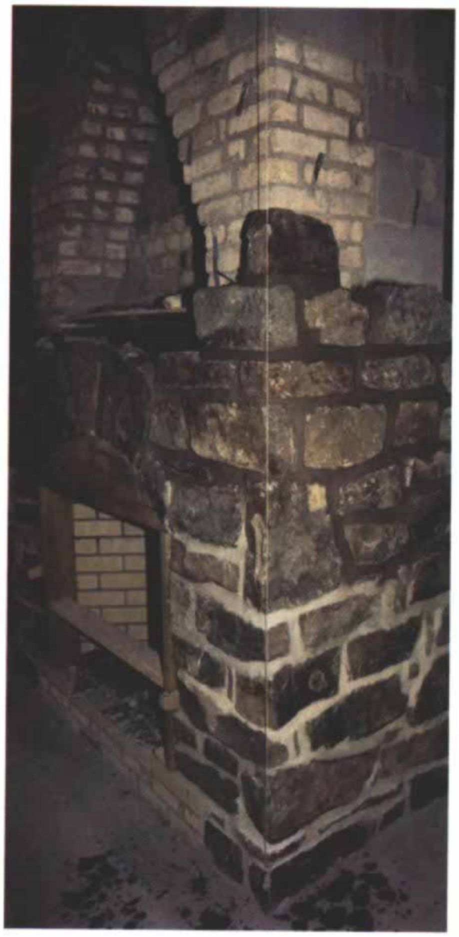
I put the head joint between the two middle firebricks on the centerline of the fireplace for a reference point and laid the rest of the hearth bricks front to back with mortar joints about ⅜ in. wide. I tooled the mortar joints with a convex half-round jointer. With the hearth floor complete, I penciled in lines for the first course of firebox bricks (photo top right, facing page).

If the finished opening of the fireplace was to be 40 in. wide, the firebox needed to be 20 in. deep, and the back of the fireplace had to be 20 in. wide. Because of the unevenness of the stone veneer, I adjusted the overall depth to 22 in. I laid the firebrick flat in what is known as the stretcher position, which made the firebox wall 4½ in. thick. This arrangement not only makes for a stronger firebox but also keeps the firebrick from burning out prematurely. Laying the firebrick in stretcher courses also provides a greater brick mass, which acts as a heat sink to radiate more heat into the room. Stretcher courses do use more firebrick than if they'd been laid on edge, but the long-term benefits far outweigh any difference in price.

Building the firebox—The bricks for the firebox were laid up in a half-lap pattern, called running bond, to a height of 20 in. as prescribed in the table. At that point I began rolling or pitching the bricks for the back of the firebox toward the front (bottom photo, facing page) so that the top of the firebox would end up at the proper depth for the damper to be set at the throat.

To figure out how much to roll each course, I first figured out how far forward the wall would have to come to accommodate the damper. That distance worked out to be 8½ in., which I divided by 11, the number of courses needed to arrive at the height of the damper. Each course therefore had to be rolled forward ¾ in. Rolling the firebrick forward caused each course in the back to be slightly lower than the side courses, so I had to add a layer of split firebrick to bring the bricks in the back even with the sides. Every few courses I embedded metal wall ties in the mortar joints on the front edges of the firebox to tie into the stonework later.

Stringlines establish the corners of the stonework. Nylon strings stretched plumb from the ceiling to metal pins near the floor work as guidelines to keep the corners straight as the stone is laid.



I parged the backside of the firebox brick with mortar to seal holes, but the angled sides of the firebox left large triangular voids between the back of the firebox and the rough block. I filled these voids with pieces of rough brick embedded in mortar, leaving a space of at least ½ in., or the thickness of a finger, between the firebrick and the rough brick to allow for expansion from heat. I loosely inserted a thin layer of fiberglass insulation behind the parged firebrick as I built it up to keep the mortar droppings out of the expansion space. Every couple of courses in height, I laid some metal wall ties in the mortar joints under the firebrick and into the rough-brick backing to tie the two together.

A custom damper is made from spare parts—I wanted to use a flat metal damper for Nick's fireplace, and none of the masonry-supply places in my area had what I needed. I wanted the damper to be made of plate steel with a lid that opened 90°. The lid of the damper had to lie on a flange that sat on the top edge of the firebox. To get the exact damper I wanted, I turned to a local metal shop.

I made a cardboard template the exact size of the damper so that the machinist could match the sides of the damper to the angled sides of the firebox. He made the damper flange and lid out of ½-in. plate steel to help prevent future warping from heat. I wanted the damper lid to open from the back instead of pivoting on a hinge or rod in the center of the lid; also, the damper lid had to be removable in case it should require service. The machinist's simple solution was welding a stop strip on the rear flange that the lid could ride against as it opens.

Next we needed something to hold the lid open while the fire was burning. The machinist offered to make something from scratch, but I ended up digging through a box of spare damper parts at the masonry-supply place instead. Sure enough, I found the notched arm assembly, and the supplier wouldn't even take any money for the parts. The machinist welded the parts in place, and we were in business. The damper cost me a total of $70. Back at the cabin, I centered the damper assembly on top of the firebox and installed it in a bed of mortar.

Corbeled brickwork supports the flue—With the damper in place, I was ready to start building the smoke chamber. I allowed for an

Fine-tuning the stone for a perfect fit. Most stonework requires some chiseling to get the stones to fit correctly. Here the author uses a standard mason's chisel to dress the face of a stone.

ample smoke shelf in back of the damper and built the back wall of the smoke chamber up to the required 29-in. height where the first flue lining would be set in place. For this wall as well as for the rest of the smoke chamber, I used hard, rough brick. I inserted some metal wall ties in the back wall at regular intervals to tie in the corbeled sidewalls.

Next I plumbed up with the level and marked the vertical centerline of the firebox on the top of the back wall of the smoke chamber. I knew from the table that I'd need a 16-in. by 16-in. flue lining for this fireplace, so I measured over 8 in. on each side of the center mark. From these points I struck a chalkline down to the top of the damper where the corbeling would begin. These lines gave me an even slope to follow as I built the sidewalls of the smoke chamber.

Before I started the sidewalls, I laid some fiberglass insulation around the ends and edges of the damper so that the damper had room to expand without cracking the masonry. Then I corbeled the brickwork up to the level of the flue lining. Corbeling is done by laying the bricks lengthwise toward the middle of the smoke chamber and letting every course project slightly beyond the course below following the snapped line. I made sure that all my mortar joints were solid and well filled. After the corbeling was finished, I rubbed down the mortar joints with a piece of burlap to smooth the mortar and to fill any holes.

Next, the flue lining was set on the corbeled edge for support. For this chimney, I had to cut the bottom of the first lining at a slight angle so that it passed through the roof a safe distance (2 in. minimum) from any combustible material such as the roof and ceiling framing. The 2-in. space was filled with fiberglass insulation. I built the chimney from that point up through the roof the same as a conventional chimney.

Starting the stonework—With the chimney and the guts of the fireplace finished, I was ready to install the stone veneer. First I established the corners for the stone veneer by dropping plumb lines from the ceiling out 7 in. from the rough masonry. I laid a couple of courses of stone in mortar for each corner, then attached a tight plumb vertical line from the ceiling joists to a metal peg inserted between the stone courses (photo p. 69). These more permanent lines then became corner guides for the stone.

Mortar tends to set more slowly in stonework than in brickwork because the bricks absorb more moisture from the mortar. So I made the mortar for the stonework more stiff than the mortar for brickwork. I attached horizontal guidelines between the corners as I worked my way around the fireplace. The trick is to allow enough time for the mortar to set up so that the stones don't sag, move around or push out. The squarest stones were used for the fireplace jambs and for the corners, and I intentionally combined different sizes to give the stonework a random appearance.

After the mortar had set slightly, I tooled the exposed joints by rubbing them with a short length of broom handle with a rounded end. I filled in holes or voids with mortar using a flat pointing trowel or flat jointing tool, pressing the mortar in firmly and then going back over the joint with the broom handle. After the mortar had set enough so that it would not smear, I brushed the joints gently with a soft-bristle brush for the final finish.

No matter how much stone you have to pick from, you'll always have to do some cutting or trimming. The stone for Nick's fireplace was no exception. I do all my stone-cutting on a heavy bench that I made out of framing lumber.

Minor trimming can be done with a brick hammer, but I use stone-cutting chisels and a hammer for most of my cutting (photo left). Stone chisels come in a variety of shapes and sizes, each with a specific purpose. Discussing all of them and how they are used is beyond the scope of this article. A basic set of stone chisels would include a pitching chisel that has a flat, slightly beveled blade used for squaring and dressing stone; a standard all-purpose mason's chisel with a wide bevel-edged blade; a toothed chisel for roughing out flat areas of stone; and a pointed chisel for removing lumps of stone too small to be taken off with larger chisels. Stone chisels are available at most masonry-tool suppliers. Wear safety glasses with side shields or goggles while chiseling stone; a glove to protect the hand holding the chisel is also a good idea.

Stone arch is built on top of a plywood form—Nick wanted an arched fireplace opening instead of the standard square opening. The basic rule of thumb for designing a segmental self-supporting arch is to make the rise of the arch no less than one-eighth of the span. At 40 in. wide the rise for this arch had to be at least 5 in. at the center point of the arch. However, Nick wanted a more pronounced curve, so we increased the rise to 12 in.

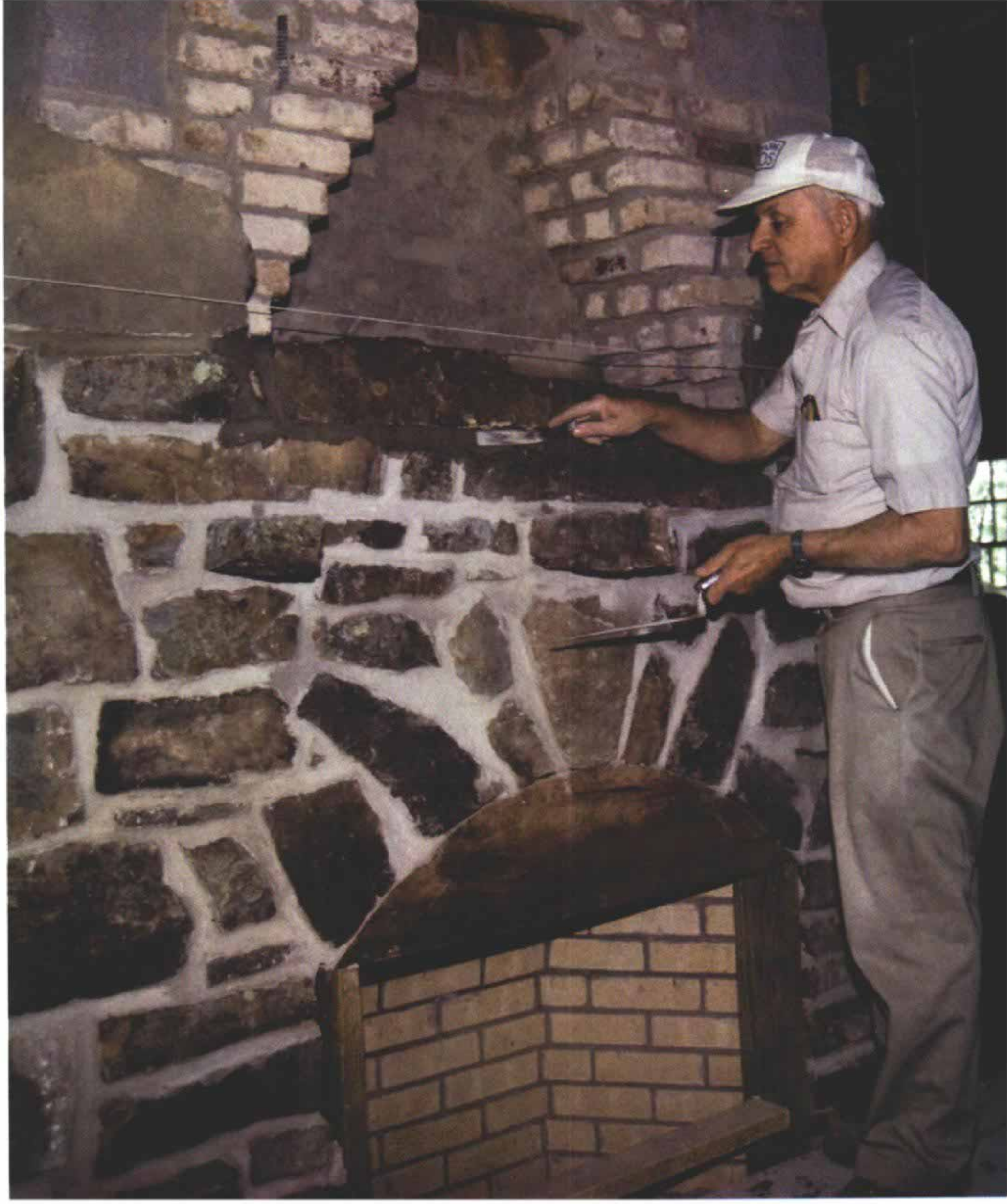
With a projected finished height of 40 in. at the center of the arch, the height of the stone jambs on each side where the arch springs from worked out to 28 in. (40 in. minus 12 in.). The next step for us was building a form that would support the arch while it was being built (photo facing page).

To avoid a lot of complicated math, I began by laying out the 40-in. square finished opening of the fireplace on a half-sheet of ½-in. plywood. Next, I measured up 28 in. on each side and drove small nails at those points. Then I marked the center point of the top of the opening, which was the highest point of the arch. Then I turned the plywood on edge with the top of the arch facing down. I tied a length of nylon mason's line to one nail and drooped the free end over the other nail. I let the line sag until the middle of the line reached the center point or the top of the arch. With a sharp pencil, I followed the line without touching it to scribe the arch.

Next I cut out the arch with a saber saw and used it as a template to cut a second arch for the other side of the form. To make the finished form close to the same width as the 7-in. stone veneer, I made supporting legs out of 2x8s along with a spreader piece that fit between the springing points. I then nailed the plywood arches to the front and back of the form and cut a series of 2x4 blocks to fill in along the curve of the arch.

I cut the legs a little short and inserted wedges under each leg to get the top of the curved form exactly level and where I wanted it. I also cut a spreader that fit between the legs near the hearth to keep the form from moving. The wedges would come in handy when the arch and the front wall over it had hardened and cured. At that point I simply had to knock out the wedges, and the form would drop free from the stone arch.

With the form in place, I selected stone that fit the curvature as closely as possible. I laid the stones across the arch with a wedge-shaped keystone in the center. No mortar was used under the stones because this was to be the finished edge. I used small wooden wedges to keep the stones in place while the mortar set up. Because the back of the arch stones formed the breast of the fireplace, I used stones that tapered toward the bottom. When the fireplace arch was finished, I parged the inside face to smooth the breast for better fireplace performance and to seal holes.



Arch is built on a plywood form. A form made of plywood and framing lumber supports the stone arch until all the stonework is finished and the mortar has cured. When the form is removed, the arch will be self-supporting. A string stretched between the corners acts as a reference to keep the stone straight across the face of the fireplace.

Proof is in the performance—I continued the stonework up to mantel height, about 60 in, from the finished floor. I'd picked out three fairly square bracket stones to support the mantel and now placed one on each end and one in the center using a line stretched tightly between the corners to keep them level.

I let the stones project out about 5 in. to support the 4-in. thick pine mantel that Nick had found at a local sawmill. We held the bracket stones in place with 2x4 props until the mortar had set up. I then could complete the stonework up to the ceiling on all four walls. We decided to install a wood mantel on the back wall of the fireplace at the same height as the mantel in front. Even without a fireplace opening on that side, the back mantel added a nice decorative touch to the massive, solid stonework.

Finally, we used large, flat stones to build a stone hearth that extends 20 in. out into the room. All the joints on top of the hearth were tooled flat so that they would not collect dirt.

I had protected the hearth with cardboard while the fireplace was being built and had been careful while applying the mortar, so the only cleaning that I had to do was removing a few particles or splatters of mortar with a stiff brush and a rounded-off piece of wood. In a couple of places, I needed a chisel to take off some stubborn lumps of mortar.

Masons sometimes wash stonework with a weak solution of muriatic acid to remove mortar stains and discoloration, but because we'd been careful, we skipped this wet, messy process. After letting the fireplace cure for two weeks, we built a test fire in it, starting with a small fire and adding wood until it was built up to a moderate size. A test fire allows everything to heat up evenly and gradually. The fireplace drew well, and no smoke was allowed into the room.

Nick has been using the fireplace ever since as the main heat source for the cabin, and one chilly raw day last December, I went with him to the cabin. We built a fire, and within minutes the cabin was warm enough for us to remove our jackets. A half-hour later, the wall of the cabin opposite the fireplace was warm to the touch from the heat radiating into the room. □

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