Technical Notes 19A - Residential Fireplaces, Details and Construction
Rev [May 1980] (Reissued August 2000)

Abstract: Brick masonry residential fireplaces can be made more energy efficient by providing a source of combustion and draft air drawn from the exterior of the structure. Proper detailing and construction can also contribute to the overall performance of the fireplace regarding both energy efficiency and structural integrity. Building code requirements often control the configuration of the fireplace as well as component sizes.

Key Words: **Bricks**, combustion chamber, energy efficiency, firebrick, fireclay, **fireplaces**, hearths, masonry, mortar.

INTRODUCTION

This *Technical Notes* contains recommended details and construction techniques which, when used to execute a proper design, will yield a functional, energy-efficient fireplace. These same recommendations are applicable to conventional fireplace construction when the provisions for the exterior air supply system are omitted.

This is the second in a series of *Technical Notes* dealing with the design and construction of fireplaces and chimneys. *Technical Notes* 19 Revised contains a comprehensive discussion of fireplace design and materials selection. Other *Technical Notes* in this series address design and construction of both residential and industrial chimneys.

RECOMMENDATIONS

General

Energy-efficient fireplaces vary only slightly from conventional fireplaces. The recommendations to construct an energy-efficient fireplace include properly sizing and locating an exterior air supply for combustion and draft air, and tight-fitting dampers. Operation of the fireplace and other devices, such as glass screens, may also substantially affect the performance of the fireplace. They are not, however, addressed in this *Technical Note.* Regardless of how much care is taken in the design and detailing process, workmanship remains a critical factor to the performance of fireplaces. The designer should, therefore, be familiar with the fireplace construction techniques of the locality in which the fireplace is to be built.

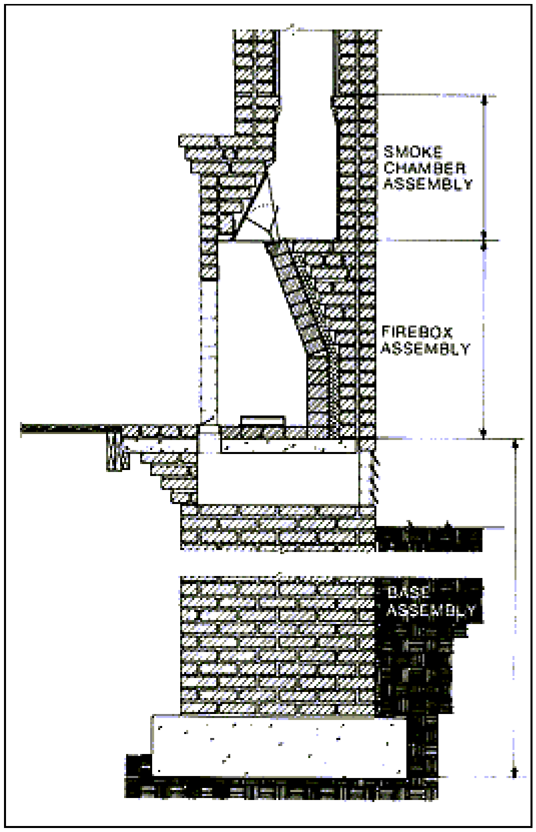
No matter which fireplace configuration is selected by the designer, there are several common features that should be considered. Fireplaces, as discussed in this *Technical Notes,* are for burning wood and are not specifically designed or constructed for fuels that generate temperatures in excess of those generated by combusting wood. The primary function of the fireplace is to contain a fire safely and deliver heat to habitable spaces.

The fireplace assembly must be isolated from combustible materials. General requirements incorporated into many building codes are: (1) All spaces between masonry fireplaces and wood or other combustible material should be firestopped by placing 1 in. (25 mm) of noncombustible material in such spaces. (2) In the plane parallel to the front wall of the fireplace, combustible material should not be placed within 6 in. (150 mm) of a fireplace opening. (3) Combustible material within 12 in. (300 mm) of the fireplace opening should not project more than 1/8 in. (3.2 mm) for each inch distance from the opening. A more specific discussion of these requirements or variations may be provided by local building codes.

All void areas within the body of the fireplace from the foundation through the chimney should be solidly filled with masonry mortared in place. The only exceptions are the air passageway, the ashpit, the 1-in. (25 mm) airspace between the combustion chamber and the brickwork surrounding it, and the functional voids of the fireplace, such as the smoke chamber.

Solidly filling the nonfunctional voids in the fireplace assembly increases its overall performance and durability as well as its structural integrity and resistance to rain penetration. All exposed mortar joints should be properly tooled. Concave jointing is preferred.

For a graphic definition of fireplace components and a section through an energy-efficient fireplace, refer to Fig. 1.



Single Face Fireplace Section

FIG. 1

FIREPLACE BASE ASSEMBLY

Foundation

The foundation supports the fireplace base and thus the entire fireplace and chimney assembly. It must, therefore, be designed to carry these loads. However, most building codes disallow using the fireplace and chimney assemblage as a structural element to support other building components. When designing the foundation, care should be taken to account for soil condition and type. Undisturbed or well-compacted soil will generally be sufficient, however, some types of soil or the condition of the soil may require additional analysis.

Building codes generally require that the foundation be at least 12 in. (300 mm) thick and, in plan view, extend a minimum of 6 in. (150 mm) beyond every face of the masonry bearing on it. It should also penetrate the frost line to reduce the possible "heaving" of the foundation, when the ground is frozen.

Exterior Air Supply System and Ashpit

There are many options to the construction methods and layout of the air passageway and ashpit discussed in this section. When varying from the suggested details, keep in mind the function which these components serve, as well as the manufacturer's recommendations for a specific device's installation.

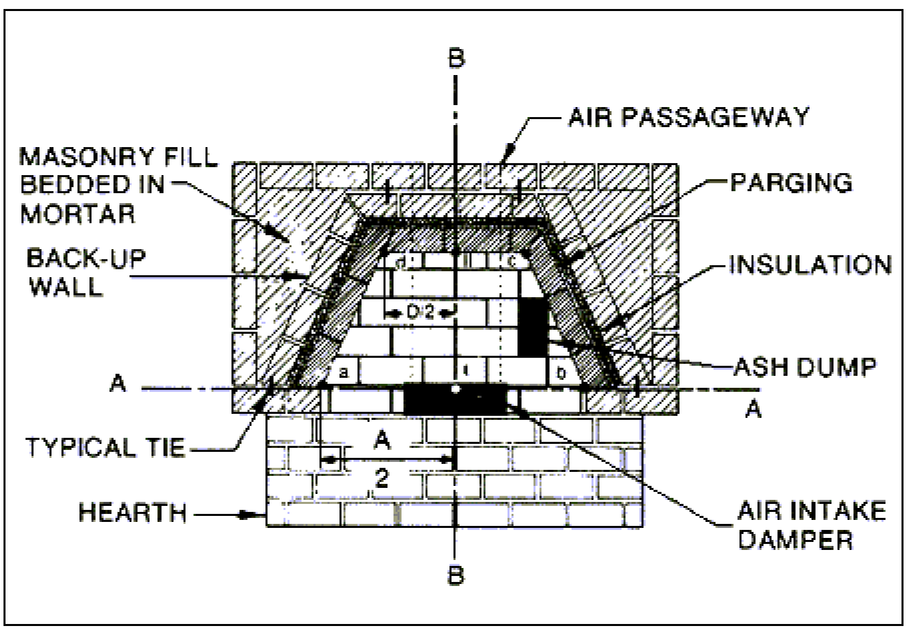
The exterior air supply system is the component that is intended to increase the overall efficiency of the fireplace by diminishing the amount of heated air drawn from the structure for combustion and draft. As discussed earlier in this *Technical Notes* this provision may be deleted resulting in a conventional fireplace design.

The exterior air for combustion and draft may be drawn directly from the exterior or from unheated areas of the building, such as crawl spaces. Local building codes may restrict the location of the air intake. For example, many do not allow air from a garage to be vented into habitable spaces. This decreases the possibility of introducing noxious gases from automobile exhausts into the house. When the fireplace configuration does not lend itself to practical incorporation of the air passageway in the base, the intake may be located on any exterior wall. No matter where the intake is located, it should be a screen-backed, closeable louver, preferably one that is operable from the interior of the building.

The air passageway is generally incorporated into the base assembly. When this is not practical due to fireplace configuration or the level of the exterior grade at the fireplace, the fireplace may be changed by raising the hearth or the passageway may be formed of ductwork and attached to or incorporated into the floor system. In many locations, the perimeter of the air passageway should be insulated, especially when the ductwork is adjacent to or passing through heated areas. Many air passageway areas have been used successfully, usually varying from 6 to 60 sq in. (3870 to 38,700 mm^2). The smaller areas may, however, yield high velocity air flow and more rapid combustion, generally resulting in higher temperatures, which may produce negative results such as fireplace grate or combustion chamber deterioration. Larger areas may also present a potential difficulty by delivering air in excess of the combustion and draft requirements. The excess air, usually below room temperature, may be forced into the room containing the fireplace. The volumetric expansion of this air due to the exterior to interior temperature differential generally compounds the problem.

The air inlet should be located in the base or sidewalls of the combustion chamber. Inlets have performed successfully, even when located in the rear wall of the combustion chamber. Care should be exercised when locating the inlet in the combustion chamber walls since an air surge may force smoke and gases into the room. The air inlet should be equipped with both directional and volume controls, so that the fire burns evenly and toward the rear of the combustion chamber. Thus, the best performance is generally achieved when the inlet is located near the front of the fireplace within the combustion chamber.

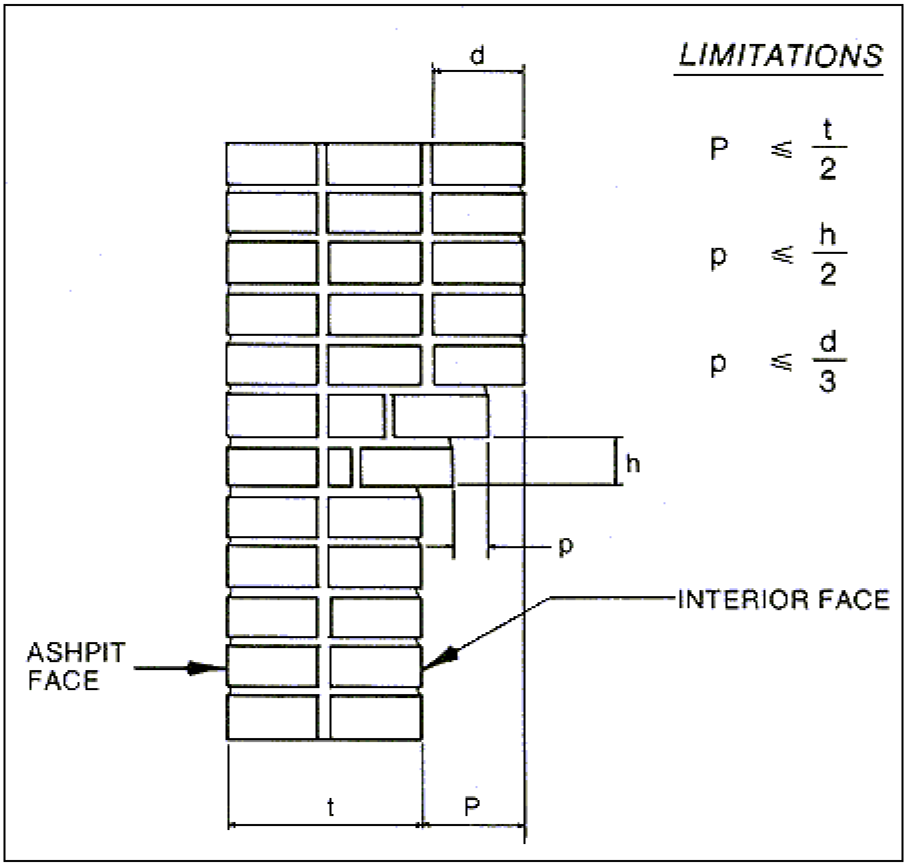
The air inlet damper assembly area, as shown in Fig. 2, generally ranges from 6 to 60 sq in. (3870 to 38,700 mm^2) depending on the other components in the exterior air supply system. The critical factor affecting the performance of the fireplace is the proper operation of the air inlet damper. Opening the damper to a position that produces an area of from 2 to 16 sq in. (1300 to 10,300 mm^2) has proven to perform successfully in most areas.



Combustion Chamber Plan

FIG. 2

If corbeling is necessary to achieve proper size or location of the air inlet, it should be limited to a maximum horizontal projection of one-half (1/2) the distance from the ashpit face to the exterior of the fireplace assembly, see Fig. 3.



Corbeling Limitations

FIG. 3

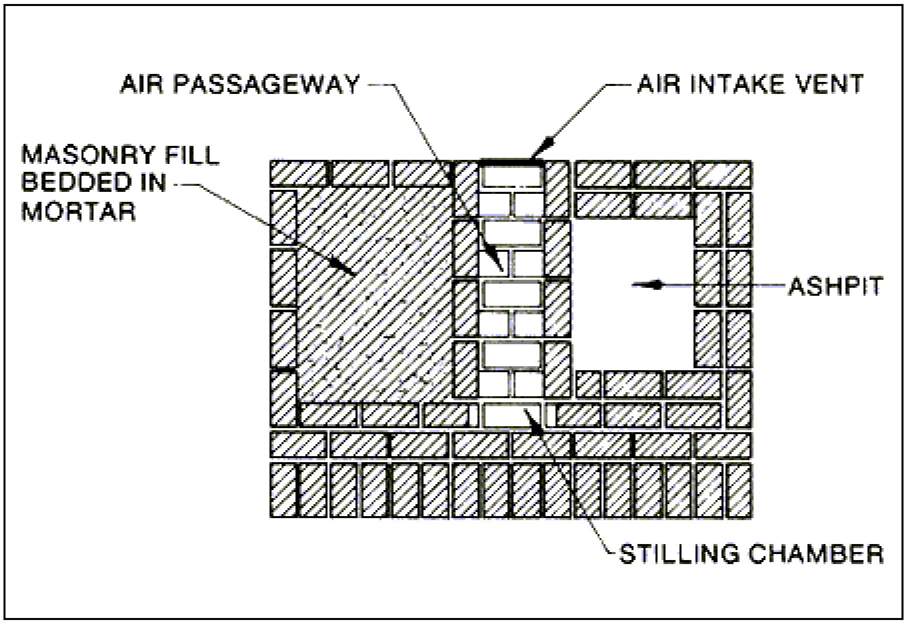
The maximum projection for an individual unit should not exceed either one-half (1/2) the height of the unit, or one-third (1/3) the bed depth.

The ash drop and ashpit are often not incorporated into the design due to either a configuration difficulty, such as slab-on-grade construction, or the absence of a desire by the designer or owner to have such a component included in the fireplace.

Figure 4 shows a plan view of an air passageway and ashpit. The ashpit cleanout door may be oriented toward the interior of the building if sufficient space for cleanout exists. The ashpit cleanout door should be metal and fit tightly to reduce air infiltration.

Hearth Support

When construction reaches the stage shown in Fig. 4, sturdy, noncombustible forming, such as metal, is set in place to contain the slab pour. This is required since this forming is inaccessible for removal and is thus a permanent part of the fireplace. In slab-on-grade construction, this requirement is not necessary unless a raised hearth is used. The blackouts that form the opening in the slab for the ash drop and air inlet should be set so that they extend approximately 1 in. (25 mm) above the top of the finished slab. This will facilitate removal of the forms. The slab should be properly reinforced when it cantilevers from the fireplace wall to the floor system or spans across the air passageway and ashpit, as shown in Fig. 1. This reinforcement is also beneficial in resisting the stresses induced by the high temperatures the slab will be subjected to. Care should be taken to keep the top of the slab as nearly level as possible to reduce the difficulty of laying the combustion chamber base.



Air Passageway and Ashpit Plan

FIG. 4

Similar results may be obtained by eliminating the concrete slab and supporting the hearth on masonry. This is accomplished by solidly filling the base assembly with masonry mortared in place. The ash dump and air passageway are formed by the judicious use of corbeling.

FIREBOX ASSEMBLY

Combustion Chamber and Firebox

Combustion chamber layout is critical since the chamber must be contained within the firebox assembly yet isolated from it. Figure 2 shows one method of properly locating the combustion chamber. Once desired dimensions have been selected from Table 1, in *Technical Notes* 19 Revised, the front wall (facing) of the fireplace is located and line A-A struck at the inside face position. Next, locate Point I on this line. Point I corresponds to the centerline of the combustion chamber in the direction perpendicular to the existing line. Squaring from Point I into the combustion chamber for the chamber's depth, defines Point II. Striking a line connecting Points I and II results in Line B-B. From Point II, squaring perpendiculars to line B-B in each direction for a distance of one-half (1/2) the rear chamber wall dimension, thus locates Points c and d. On line A-A, measuring from Point I one-half (1/2) the fireplace opening dimension in each direction, thereby defines points a and b. Connecting these four points (a, b, c and d) gives the outline of the inside face of the combustion chamber.

Preferable combustion chamber construction consists of firebrick, in accordance with ASTM C 64 and fireclay mortar, in accordance with ASTM C 105. Fireclay mortar joints should be 1/16 to 3/16 in. (1.6 to 4.8 mm) thick to reduce thermal movements and mortar joint deterioration. When using fireclay mortar, extremely thin mortar joints may be obtained by using the "Pick and Dip" method. This consists of dipping the unit into a soupy mix of fireclay mortar and immediately placing it in its final position. The mortar joints need be only thick enough to provide for dimensional irregularities in the unit being laid.

Acceptable construction includes the use of Grade SW brick, in accordance with ASTM C 62 or ASTM C 216, and Type N or Type O. portland cement-lime mortar, in accordance with ASTM C 270 or BIA Designation M1-72. Type N or Type O, portland cement-lime mortar may also be used with the firebrick option. Mortar joints should be limited to 1/2 in. (12.7 mm) maximum and be properly tooled, resulting in a concave profile when using the portland cement-lime mortar.

The brickwork surrounding the combustion chamber may be brought up, either at the same time as the combustion chamber, or after it has been completed. In any case, there should be a full course of masonry surrounding the combustion chamber, to allow for solidly filling the void created and maintaining a minimum 1-in. (25 mm) airspace between the firebrick and surrounding brickwork, see Fig. 2. This airspace may be filled with a compressible, noncombustible material, such as a fibrous insulation. The purpose of this material is to keep the space clear of obstructions. Either the airspace or the compressible, noncombustible material reduces the stress from thermal movements by isolating the combustion chamber.

The wall behind the firebrick at the rear of the firebox should be at least 8 in. (200 mm) thick. A greater thickness may be required to support higher chimneys.

With the exception of the combustion chamber walls, wall ties should be used at all intersections where the wall is not masonry bonded. These ties should be spaced a maximum of 16 in. (400 mm) vertically, and embedded at least 2 in. (50 mm) into bed joints of the brick masonry.

Horizontal joint reinforcement may also be beneficial, most especially at the corners of adjacent wythes and in the wythe surrounding the combustion chamber walls. This precaution should help reduce cracking at these areas.

The combustion chamber walls should be firebrick. Firebrick may be laid with any face exposed, but they are preferred as a stretcher course. However, if Grade SW brick are used, they should only be laid as a stretcher course since they may not be as durable as the firebrick.

No fires should be built in the combustion chamber for thirty (30) days after construction. Fires before this time period drive off the moisture necessary for proper curing of the mortar.

Lintels

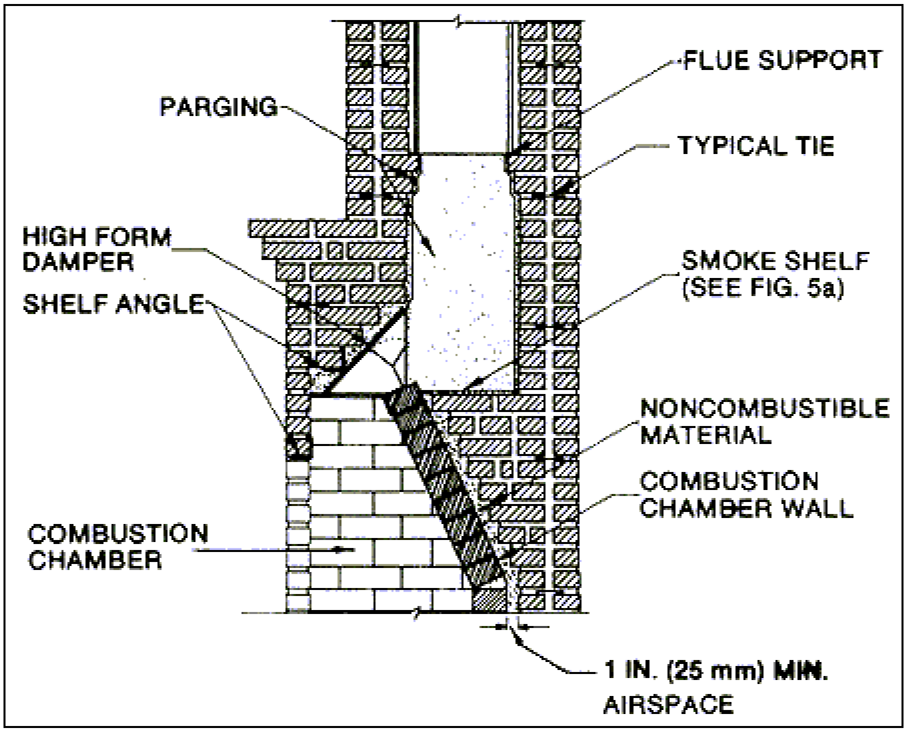
When placing the lintel above the fireplace opening and the lintel above the damper, a compressible, non-combustible material, such as insulation of a fibrous nature, should be placed at the end of the lintel where it is embedded in masonry. This precaution is a means of dealing with the dissimilar expansion characteristics of masonry and steel, which tend to induce stresses in the masonry, causing cracking.

The use of a lintel above the damper is highly recommended. his lintel is provided so that the masonry does not bear directly on the metal damper which is subjected to extremely high temperatures, and high magnitude thermal movements. All lintels used in the fireplace should bear on the brick masonry at least 4 in. (100 mm) at each end.

Damper

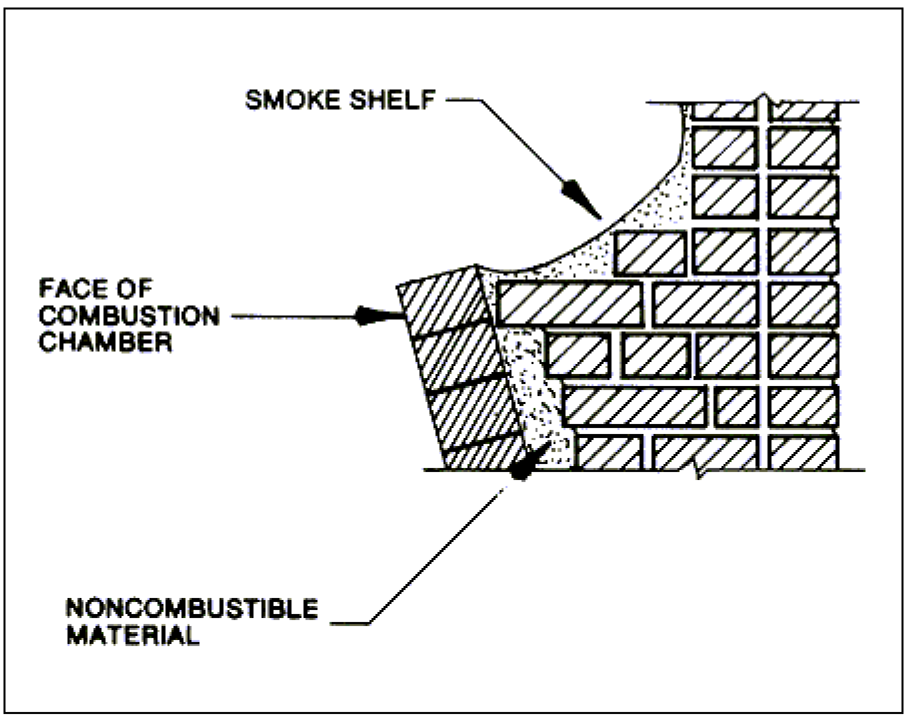
The damper is then seated using the same mortar that was used in the combustion chamber. This is accomplished by spreading a mortar bed, just thick enough to ensure a level set of the damper and a seal that will prevent gas and smoke leakage. The damper should not be embedded in mortar, but merely seated on the thin setting bed.

The damper assembly should only be in contact with masonry, on which it bears. To ensure this, once the damper assembly is seated, it should be wrapped with a compressible, noncombustible material, such as fibrous insulation, see Fig. 5. This material provides space for thermal expansion and movement of the damper during fireplace operation.



Combustion Chamber and Smoke Chamber

FIG. 5a



Optional Smoke Shelf Configuration

FIG. 5b

SMOKE CHAMBER ASSEMBLY

Beginning at the level of the smoke shelf, the front and sides of the smoke chamber are corbeled in and the rear wall is constructed vertically. This ensures total perimeter support for the flue liner. Corbeling limitations for this component are determined by the fireplace configuration itself. The maximum corbel for each unit is the horizontal distance to be corbeled divided by the number of courses from the bottom of the flue liner to the first corbeled course. The usual limitations for corbeling walls are not applicable in this area of the fireplace since the corbels are continuously laterally supported by adjacent masonry. The last two courses before the flue liner should be laid as headers. These headers should be cut to a length that provides total perimeter support of the flue liner, without obstructing the flue liner opening.

The smoke shelf may be a flat surface or curved, to assist flow through the smoke chamber, see Fig. 5a. The entire smoke chamber should be parged. Care should be taken to ensure that the smoke shelf is kept free of mortar tailings and debris for the same flow considerations. This may be accomplished by placing a material such as an empty cement bag or plastic film on the smoke shelf during construction. When construction is completed, it can be removed through the damper throat, bringing any foreign material with it.

SUMMARY

This *Technical Notes* has given suggested details and construction techniques for single-face residential fireplaces. Other *Technical Notes* in this series address fireplace design, as well as residential and industrial chimney design and construction. Emphasis has been placed on workmanship and proper construction methods.

It should be noted that all fireplace designs, no matter how sophisticated, are empirical and based on past performance of specific configurations. Any variation from these configurations produces an "experimental" design. While small deviations from the dimensions and proportions given may have little or no effect on performance, larger magnitude changes should be carefully considered since they may have serious negative effects on the function of the fireplace.

The information and suggestions contained in this *Technical Notes* are based on the available data and the experience of the Brick Industry Association’s technical staff.

This information should be recognized as recommendations and suggestions for consideration by the designers, specifiers, and owners of buildings when anticipating the design, detailing and construction of single-face residential fireplaces. The final decision to use or not to use these recommendations and types of products in brick masonry fireplaces is not within the purview of the Brick Industry Association and must rest with the project designer or owner.

REFERENCES

1. *One and Two Family Dwelling Code,* published by Interstate Printers and Publishers, Danville, Illinois, 1975

2. *Book of Successful Fireplaces, How to Build, Decorate and Use Them,* 20th Edition, by R. J. Lytle and Marie-Jeanne Lytle, Structures Publishing Company, Farmington, Michigan, 1977.

3. *How to Install A Fireplace,* by Donald R. Brann, Direction Simplified, Inc., Briarcliff Manor, New York. 1976.