In the last issue we discussed main areas of consideration for furnace construction and putting bricks together. We started examining aspects of A to K in Figure 1. We will continue with aspects of A to K that are common to all types of glass furnaces.

The purpose of Figure 1 is to provide information about materials and placement of materials. It is not a diagram of an actual furnace, although some furnaces may look like this.

You will notice that Figure 1 does not have an exhaust port. That is because exhaust design will depend on the type of furnace, and we will discuss specifics about furnace types after examining common aspects of A to K.

**FIGURE 1 KEY:**
- A: Insulation, roof or crown insulation
- B: Outside Wall
- C: Roof or crown
- D: Burner Block
- E: Burner
- F: Inside liner, above glass liner, hardface
- G: Insulation, walls and floor
- H: Inside liner, hardface, glass tank liner
- I: Hot Glass, Glass Tank
- J: Base Plate
- K: Legs, supports

**B: OUTSIDE WALL**
If you are making a brick unit using compression, the outside wall is simply the last layer of brick. If you are casting or using loose vermiculite for wall insulation, the outside may be sheet metal or thin plate steel held in a metal (usually angle iron) frame. Another option is to mortar or compress the outer brick wall and then pour or cast insulation. The outside wall can be anything fireproof. Some furnaces have a 50 gallon steel drum for the outside wall thus making a small round furnace.

If you are making a compressed brick day-tank, it is logical for the outside wall to consist of the last layer of brick. Otherwise, the most cost-effective wall is sheet metal held in a lightweight angle iron frame. The furnace base may be heavy duty angle iron, but the walls can use lightweight small angle irons.

Beginners Tip: To save on angle iron: Design and make the wall frame of 1/2" or 3/4" lightweight angle iron. This will be a square or rectangle. Then cut the flat piece of sheet metal that will fit the frame and insert it. Push on the sheet metal and...
notice where it is weak and floppy, and determine where to brace the frame with more angle iron. To test a brace, clamp it on with vise grips, then push on the sheet metal. This will help you to determine good bracing with the minimum amount of angle iron. When you know where to put the braces, weld them in place.

If you come across a large number of used or inexpensive 2000 degree F insulating firebricks you can make an outside brick wall. In my experience, it is more cost effective (labor and durability and ability to take it apart) to compress an outer brick wall rather than mortar it.

C: Roof or Crown

The roof or crown of the glass furnace must be made of a very special hard material (usually non-insulating) which can withstand 2400 degrees F or more without cracking or spalling, and which will resist attack or corrosion from glass making chemicals (fumes).

The best material for this is Mizzou castable refractory manufactured by A P Green and sold by most refractory dealers. To use this castable you must carefully follow the manufacturers instructions. Determine the size and shape of your roof and make a waterproof mold in which to cast the material. If the roof is flat, it is very easy to make a box for a mold and line it with plastic sheet material.

I have tried a number of castables that should or could replace Mizzou, with poor results. My results with Mizzou have been excellent, with very long life for the roof (four to five years and longer).

There are other materials that are good, and I will leave it to members of the information exchange to discuss these (send your letters) because I have not had the opportunity to try some of these. It is possible that if the furnace is very large, a castable such as Mizzou would not be as good as a manufactured roof material made for glass furnaces. Meanwhile, for the average studio, it is very beneficial to use Mizzou.

Shape of The Roof: Some people like to have arched or dome roofs. The reason is that they are considered to have more strength and more radiation surface. I have good results with flat roofs. Most of my cast mizzou roofs are 2 inches thick. I originally used the traditional method of placing the roof horizontally on top of the glass tank. After wondering why one should waste all that extra space in back, I tried a shed roof (sloped roof) and it works just fine. A furnace chamber does need enough combustion space, but I feel that even with a side fired day tank, the shed roof will help to decrease the amount of bricks being kept hot, and thereby decrease the fuel consumption.
Brick roofs: Some furnaces have arched hard-brick roofs. These are difficult to construct and they are difficult to repair or replace. They do offer superior spanning support over larger areas, but they do not appear to be necessary in the average glass-art (small) studio. Information about using special brick shapes to build arches is available from A P Green refractories.

Conclusion: It is best to cast a mizzou roof, unless you find very specific information about another material. That information should come from someone who is using it for glass furnaces, and who has proved that it works for glass. If you build a very-mini tank you can use hard brick if it is large enough to lay flat across the top.

D: BURNER BLOCK

My furnaces have burner blocks made of cast Mizzou. I size the outside of the burner block to match the furnace construction, so that it fits easily into the brick sizes and wall sizes. This saves the trouble of custom cutting and fitting little pieces of brick or other material when assembling the furnace wall. The block, with the round tapered hole in it, fits nicely into the wall as the wall is being built up.

If you use a pre-mix burner, the burner block is one of the most important parts of your furnace—for safety and for economy of operation. You will benefit by putting a lot of effort into making a good burner block and burner mount. (For burner mounts see issue # 15).

Here are some tricks and tips about the burner block that help reduce trouble and danger.

The burner head (tip) is a round ceramic shell with a flat face. (Metal tips are also available). The face has holes through which the which the gas/air mixture exits. The purpose of the burner head is to contain the gas/air mix and cause it to burn exterior to the face of the burner, producing a quiet, efficient flame. This is achieved by controlling the exit velocity of the gas mixture. (Small holes for small amounts of gas mixture going through, larger holes for more powerful burners.)

If the flame velocity is too slow relative to the size of the holes, the gas can burn inside the head. This is called pre- combustion or burn back. The head and the pipe leading to it can become red hot. It makes a lot of noise. It is a dangerous situation. If the velocity is correct, but other factors cause the head to become too hot, the result will also be precombustion.

The burner head can be inserted into the furnace opening, but it is not necessary to do so. For long burner head life and efficient combustion it is important to keep the burner head cool. Reducing thermal shock to the ceramic material causes it to have a very long life. Therefore you do not attempt to recuperate (pre-heat) the combustion air, and you do not have to push the burner head into the furnace or glory hole.

The purpose of the burner block is to help keep the head cool and to benefit flame velocity. It has been my experience, that it is beneficial to place the burner head face flat against a round hole which opens into the furnace. As the hole opens
into the furnace it should taper larger. This assists in flame propagation and velocity.

I use Giberson Ceramic Burner Heads. [Write to Dudley Giberson, Joppa Glassworks, Inc., Box 202, Warner, N.H. 03278] The outside diameter is 4". The diameter of the circle of holes in the face is 3 3/4". Therefore, the small aperture of the burner block is 3 3/4", and it tapers up to 6" or 6 1/2".

A new ceramic head is now being made by Paul V. Wilton [Wilton Technologies, 2932 Via Loma Vista, Escondido, CA 92029]. I have not had the opportunity to try these, so let us know how you like them.

Gently placing the burner head flat against the burner block, and locking it in place with a secure burner mount, will give you trouble free performance if correct velocity is maintained. Remember that physical abuse and excessive thermal shock can destroy a ceramic head. A ceramic head used properly will last many years.

BEGINNERS TIP:

It is possible to cast a burner block with a very smooth, flat face. The burner should fit nicely and will not require a gasket. If the face of the cast mizzou block is not perfect, some flame might leak out. You can still use the block. Cut a circle (3 3/4") in a piece of ceramic refractory blanket and use this as a gasket between the burner face and the burner block. Make sure the burner holes are free, not blocked by the burner block or gasket.

![Burner Head Diagram]

**BOOK REVIEW**

Well folks, you asked for it, and now it is here. GLASS NOTES, a reference book for the glass artist, has been written and published by Henry Halem.

Henry Halem has spent the last 25 years teaching glass at Kent State University in Kent, Ohio. His book originated from handouts and reference materials from his teaching files. It also includes historical reminiscences, Stanislav Libensky and Brychtova material, and contributions from Fritz Dreisbach, Mark Peiser, Nick Labino, Bill Carlson, Bob Carlson and Danny Schwoerer.

Many members of The Independent Glassblower have requested furnace building information, which we are working on now. Henrys' book has furnace building information for a pot furnace and for a day tank, with diagrams, methods & suppliers. This is only part of it. Topics include glory hole, annealers, copper electroforming, silver, lusters, enamel, sandblast, molds for mold blowing, casting, glass chemistry, annealing and more.

This excellent reference book is a must for beginners, old timers, and everyone in between. To order your copy, see the information on the advertising page of this issue.

Thank you, Henry, for making a significant contribution to the world of the studio glass artist.