Ceramic Arts Handbook

by Vince Pitelka

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Preface

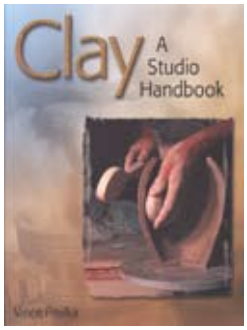
This *Ceramic Arts Handbook* is an abridged version of Vince Pitelka's best selling *Clay: A Studio Handbook* (The American Ceramic Society, 2001). His book has sold thousands of copies and is used both as a textbook and reference resource in thousands of ceramics studios in art schools, community art centers, colleges, universities, and homes. While the book authoritatively explores each topic in great detail, we've extracted some of the basic essentials you need to get you started on your clay adventure.

In his introduction, Vince writes "Through 30 years of experience as a studio potter, welder/fabricator/mechanic, and university educator, I have been collecting and disseminating information about ceramics. This book is a compilation of what I feel will be most valuable to ceramics students, studio artists, and educators, regardless of the particular direction of their ceramic work or teaching. I hope it will provide a convenient reference to help you through most of the steps in skill development, studio setup, and operations. It is my intent to offer answers and stimulate ideas."

Working in clay is one of the most rewarding activities. It's suitable for all age groups and personalities and provides challenges for every skill level. We believe that this Handbook will provide you with a deeper understanding and appreciation of this medium, and hope that you'll be able to spend many joyful hours ahead with your hands in clay.

Bill Jones

Ceramic Arts Book Manager



Clay: A Studio Handbook
by Vince Pitelka
The American Ceramic Society, 2001

Clay and Claybodies

Chapter 1

The Nature of Clay

We who work and play in clay have chosen well. Clay is among the most abundant and inexpensive materials on earth. The natural processes that weather and decay igneous rocks have been generous in providing us with extensive clay deposits in a variety of forms. Clay is abundantly available almost everywhere on earth, awaiting our need, often requiring little processing.

Clay is a remarkable material for so many reasons. There is no other art or craft material that has the versatility and possibility of clay. We can cast it, throw it, extrude it, model it, roll it, pinch it, press it, slump it, stamp it, pull it, and push it. We can use it to create any form or shape, tiny or monumental, organic or rectilinear, thin and fragile, or thick and heavy. It is the most malleable and forgiving of art materials. It asks little of us, but with commitment and respect on our part, it rewards us generously.

When subjected to a simple firing process, clay is transformed to hard, impermeable stone, and what was once so malleable and impermanent might now remain stable and unchanged for millennia. As if the mere workability and fired permanence of clay were not enough, we can also apply an unending variety of mineral coatings that fuse into glassy glaze surfaces of unlimited color and texture. When you place a lump of clay in anyone's hand, the response is automatic. The hand closes and squeezes the clay, and a unique sculptural form is produced, subtly different from any other before. Few of us stop at that point, for the clay encourages us to apply different forces, responding to every push and pull. Until the clay begins to stiffen, there are no rules, and no externally imposed finality. We can undo what we have done, and we can immediately return any form or shape to a simple lump and begin anew.

We do not know what we *can* do until we find out what we *cannot* do, and in order to fully discover the possibilities, we must take chances and experience lots of failure and mistakes. When in doubt, make something. Never allow frustration or failure to drive you from this medium.

Do not *ever* stop experimenting and exploring. Do not be satisfied with a single direction in your work. Do not become smug with any aspect of the medium, no matter how well you think you know it. The clay will catch you off guard and will throw you for a loop every time. But as long as you maintain a spirit of discovery and curiosity, the clay will reward you frequently and generously.

What Is Clay?

Clay results from the natural decomposition of certain igneous rocks—primarily granite and feldspar. The end result of the decomposition of granite and feldspar produces microscopic flat clay crystals called *platelets*.

When microscopic clay platelets are wet, they tend to stick together and slide smoothly against one another. The most plastic clays are those with the smallest particle size.

Different clays behave differently depending on the range and distribution of particle size and the presence of non-clay contaminants, primarily organic materials and nonplastic minerals.

How Does Particle Size Affect Drying and Firing?

The size and shape of clay particles help determine plasticity, but they also have profound effects in drying and firing the clay. The evaporation of the water layer existing between each particle in the plastic state is what causes drying shrinkage. The finer the particle size, the more water layers are present, and therefore the greater the water content, and the greater the drying shrinkage. But at the same time, the finer the particle size, the more contact points between particles in the dry state, which gives greater dry strength in greenware and more bonding surfaces in the early stages of the firing. The ideal condition is to have a mixture of sizes of clay particles. This creates as much contact surface as possible between particles, giving good plasticity, dry strength, and bisque strength, and yet it minimizes the water content and resulting shrinkage.

Claybodies

Claybodies are mixtures of clay and other materials designed to accomplish specific goals like plasticity in throwing, stability in large-scale work, thermal shock resistance, dry and fired strength, or vitrification and density.

Earthenware claybodies remain porous at low-fire, and yet at higher temperatures will likely deform and bloat before vitrification. Traditional earthenware bodies are usually red or buff, a blend of iron-rich surface clay plus sand or grog to give structure and often with fireclay or stoneware clay to increase firing temperature and reduce the chances of deformation and bloating. Modern low-fire bodies are often white, composed of 50-50 ball clay and talc, and are actually very similar to ones used by the Egyptians 5000 years ago.

A low-temperature firing process does not necessarily mean an earthenware or whiteware clay—the raku and bonfire processes often use highly refractory stoneware bodies that are simply underfired at low-fire temperatures and are therefore very porous and open, giving high thermal shock resistance. Low firing is especially appropriate for large sculptural work, as there is little or no shrinkage in low firing, and common problems with cracking and warpage are minimized.

Porcelain claybodies include gritless high-fire bodies that fire close to pure white. Under certain circumstances, fired porcelain can be translucent. True bone china (traditional translucent porcelain) is so-titled due to the addition of bone ash (calcium phosphate). Bone china bodies are very prone to warpage unless fired on flat shelves with no hot spots in the firing. Actually, any reasonably well-fluxed cone 10 porcelain thrown very thin will give some translucence without the disadvantages of bone china.

Stoneware claybodies use natural stoneware clay and/or fireclay as a base, with additions of ball clay, kaolin, flint, fluxes, and/or grog or sand. Whiteness is rarely an issue, so the materials are selected for desirable performance in forming and firing, regardless of color. Natural stoneware clays and plastic fireclays with the addition of ball clay produce an extremely plastic throwing body. Adding sand or grog gives *tooth* or structure in the plastic state and reduces slumping during throwing or handbuilding, allows thinner, taller wares with greater horizontal extension, and reduces drying shrinkage. •

Handbuilding

Chapter 2

With handbuilding, the full scope of sculptural form and expression is available to the potter and the sculptor. It offers innumerable possibilities in structure and surface that are impossible or impractical on the wheel. With handbuilding processes, one can construct almost any imaginable shape. These processes are divided into three main categories: pinch, coil, and slab construction. Pinch and coil construction are the prevalent forming methods in all ancient and tribal cultures. Slab construction was widely used in Meso-American pre-Columbian cultures, but otherwise is rarely found until modern times. Pinch construction is by far the simplest of these processes and provides the ideal introduction to all other ceramics construction methods. Pinch forms are usually confined to less than six inches in diameter, although there are exceptions to this. Pinch forms can be made either very thin and delicate or thick and substantial. There is something quite remarkable about an eggshell-thin pinched form, sanded and burnished, and blackware bonfired to a satin black luster.

Coil constructed forms can take almost any shape imaginable. Coiling is the only method where novices can quickly learn to make very large vessels or sculpture, and the experience can rapidly increase their confidence in clayworking. Coiling is especially appropriate for organic forms, large volumetric vessels, and figurative sculpture.

Clay slabs can be worked in either the soft-slab or stiff-slab method, indicating the condition of the slab while it is being worked. The soft-slab method is appropriate for slumped, draped, or soft-formed vessels, for clay masks, or for draping onto forms to make components to be stiffened and assembled. It is also ideal for making a wide variety of curvilinear and organic forms. The stiff slab technique is more appropriate for rectilinear and architectural forms, although the two approaches can be combined. Even for hard-edged geometric forms, many sculptors and vessel makers slump-mold curved components and assemble them leather-hard along with flat, stiff-slab components.

Wedging the Clay

The wedging process is important in all ceramic construction techniques, as poorly wedged clay simply does not respond well. Wedging mixes and homogenizes the clay and eliminates air bubbles. Do not *ever* settle for clay that is too wet or too dry—it simply isn't worth it. With clay that is too wet it is a simple matter to wedge it on a dry plaster slab, or to slice it, stand the slices vertically and allow them to stiffen up. Any clay that is too dry can be sliced, wetted down, and left in a bag or barrel overnight to absorb the moisture. If you stiffen or soften your clay by these methods, be sure to wedge it very thoroughly before using it.

When first learning to wedge, cylinder wedging is usually the easiest approach to master. Start with a ball of clay that you can comfortably stretch your fingers around (like a large orange). Set the ball on a flat surface, preferably a canvas-covered table. Hold both hands as you would to shake hands with someone, and grab the ball firmly with your hands wrapped around either side, as indicated in **Fig. 2.1**. Applying pressure downwards against the table, push the ball away from you slightly, moving it two or three inches so that the bottom smears forcibly against the table. Roll the ball back up towards you (standing it up on the smeared "extension"), grab again on either side as before, and push down and away as before. Repeat this at least 20 times for each lump of clay. This process creates a spiral twisting and stretching within the lump, homogenizing any irregularities in composition or moisture content, and more importantly, eliminating air bubbles. Remember not to push down from above, flattening the lump, and be sure not to push so hard on each stroke that you smear the ball out too flat, because when you stand it up and push again it will fold over on itself, trapping air instead of eliminating it. Each push should just smear the bottom of the lump over a little, without ever trapping more air in the clay.

Generally a minute or so of wedging is enough, but, if you are blending different clays or working dry material into overly wet clay, it may take considerably more wedging. If the clay lump begins to elongate to either side, slap your palms against it to narrow it.

Handbuilding: General Guidelines and Suggestions

The following guidelines and suggestions apply to all clayworking, but especially to handbuilding. If you familiarize yourself thoroughly with these guidelines, the learning curve will be accelerated.

Commanding Approach: Clay appreciates a vigorous, commanding approach with an economy of motion. Whatever you do, do it for a specific reason. With an aggressive, adventurous approach, you will learn much faster than with a weak, tentative approach.

Clay Consistency: Always start with well-wedged clay of an appropriate stiffness or softness for the desired project.

Forming Method: Use the method appropriate for the forms you wish to make—for organic shapes use coil, pinch, or soft slab, for geometric shapes use coil or stiff slab.

Awareness of Surface Effects: With an appropriate forming method and sensitivity to the surface created during initial construction, subsequent surface finishing may not be necessary. The forming or assembly process itself can often create patterns or marks that are very pleasing.

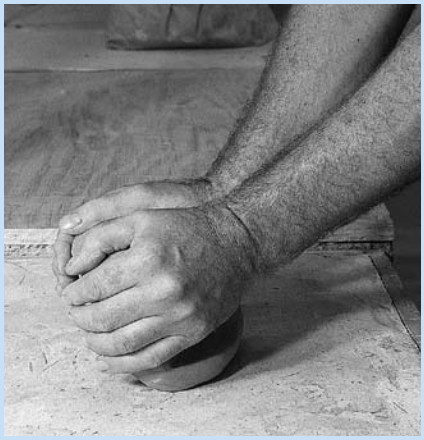
Concentration of Pressure Points: All stages of manipulating the clay depend on concentration of pressure points, giving you much greater control than with a broad application of pressure over a large area. EVERY part of your hand is useful. Remember that for every action there is a reaction. Keep in mind the consequences of every type of pressure that you apply to the clay.

Wall Thickness: Make pieces only as thick as is necessary. Extra thickness *does not* necessarily increase structural integrity. In tall pieces you may wish to make the lower walls slightly thicker, but otherwise maintain uniform thickness. For most sculpture and vessels, even a very large piece should not be more than ¾" to 1" thick anywhere.

Base Support and Bottom: Always construct large forms on a sturdy movable board, with several layers of newspaper under the clay to prevent sticking and to allow for contraction of the piece during drying shrinkage. On coil or slab work, always build on top of a bottom slab

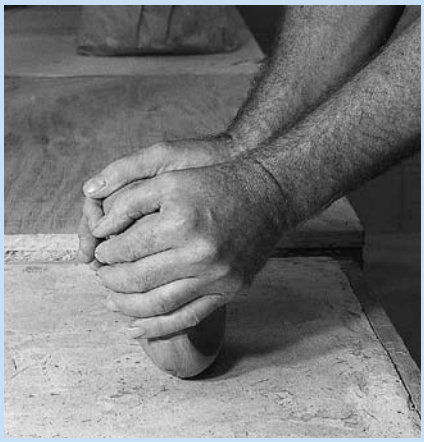
Figure 2.1 Cylinder Wedging

Place hands on either side of the lump in handshaking position.



Lean into the lump.

Continue leaning into the lump, smearing the lower portion against the wedging table.



Roll the top of the lump directly up towards you and grasp the sides.

Lean into the lump again, roll it back towards you, and repeat.

Continue until the lump is well blended and shows this appearance.

of clay. Whenever possible, have a single continuous base that supports all parts of a piece. For example, if you are building an animal form with delicate legs, incorporate a base as part of the piece, thereby supporting and protecting the legs.

Closed Spaces: Never create completely closed spaces, as they will trap steam pressure and may explode in the kiln. Always make breather holes. Tiny pinholes are adequate, but make several in case one becomes clogged. Whenever possible, ALWAYS leave larger breather holes. Never apply additions or appliques in such a way that air is trapped beneath them.

Joining: Always join clay aggressively and firmly in a way that is appropriate for the consistency of the clay. NEVER press clay straight together without proper preparation, as this will result in the alignment of particles in a fracture plane. Soft clay may be joined without scoring or slurry, especially in coil construction, as long as the pieces are smeared thoroughly together, blending the seams inside and out to ensure thorough interlocking of the particles. In all other circumstances, when joining parts or adding soft clay or appliques to a surface, score thoroughly with a fork or toothed rib, be sure to use enough slurry to force out all air bubbles, and press the parts in place firmly to eject all excess slurry. With leather-hard clay, always fit the pieces well,

score thoroughly, use a generous amount of slurry, and immediately join the pieces with firm pressure. In joining component parts or slabs, whenever possible score the inside of the joint and press in a small coil of soft clay along the seam. Ideally, pieces to be joined together should be the same consistency and stiffness. However, this is not always possible, and when joining pieces of dissimilar moisture content, cover the assembled form and allow the moisture content to equalize before allowing the form to dry. Do not attempt to join pieces that have dried beyond medium leather-hard, except when using paper clay techniques.

Stages of Leather-Hard:

Soft leather-hard is the stage where you can easily pick up a small or medium-size piece without distorting it, but the surface is still a bit tacky. When trimmed with a trimming tool, the trimmings tend to ball up and stick under the tool, and the form is easily distorted or damaged. This is an ideal stage for joining parts, as long as they can be handled without serious damage.

Medium leather-hard is the stage when all surface tackiness is gone, and plastic clay will not stick easily when pressed against the clay. When the surface is incised with a modeling tool, the displaced clay rises in attached ridges along the groove. When trimmed, the trimmings fall freely away, and will not stick to the surface or the trimming tool.

Hard leather-hard is the stage where the color is still "damp," but the clay is too stiff for easy trimming. When incised with a wooden or metal tool, the surface feels scratchy, and the displaced material falls away freely as small particles. Many people like to carve the clay at this stage, although a point between medium and hard leather-hard is usually more desirable. This stage is appropriate for thin surface painting, but not for thick slip techniques like slip-trailing. Once the clay has begun to bleach (lighten in color from drying) it has passed beyond the leather-hard stages.

Assembly: Regardless of forming method, it is often advantageous to build large pieces in sections to be joined when soft or medium leather-hard or to be fired separately. After the fire, they may be stacked loose, assembled on an armature, or cemented together with epoxy or silicone adhesive.

Avoid Using Water: Do not use water to smooth or finish a piece as you work on it—it will just soften the clay, removing structural integrity and making it harder to work. Do not use water in place of slurry when joining pieces, except perhaps with very soft clay. Otherwise, it may just lubricate the clay surface and encourage the formation of fracture planes. You may, of course, use water (applied with a sponge, brush, or spray bottle) to slow down the drying process whenever it is proceeding too rapidly.

Working in Stages: Each part of the process should be done at the appropriate stage of softness or hardness. When constructing large shapes consider the clay's ability to support higher sections. Do not attempt to keep working beyond the clay's ability to support itself. With large pieces, cover the surfaces where more parts are to be joined, and allow the rest of the piece to stiffen before continuing (or accelerate stiffening with a hair dryer or propane torch).

Structure: At all stages, consider the structural integrity of the clay (in both wet and dry stages) and its ability to support the upper portions of the piece. With large sculptural forms, cross brace the interior. Always support horizontal protrusions or extensions with a temporary prop until they are firm enough to support themselves. Do not overlook the possibility of using wadded newspaper as an interior support to maintain the shape of closed forms or to support relief forms such as masks. It may be left in place and will burn away in the firing.

Controlled Drying: Always carefully control the rate and degree of drying. When time constraints demand it, large pieces may be stiffened with a heat gun, hair dryer, or propane torch before continuing with construction, but this can result in uneven stresses on the clay. When necessary during construction, pieces may be moistened with a spray bottle to retard drying. Any large pieces to be left covered with plastic should first be draped with a large cloth (old towels or bed sheet) to absorb and dissipate moisture. Otherwise, condensation under the plastic can run back onto the piece in concentrated areas, possibly causing collapse. Large complicated pieces should be kept covered and allowed to dry very slowly. Small

parts that protrude from a form must be protected from quick drying, especially if they attach in two or more separate places. The easiest solution to this problem is to coat those parts with wax resist. This will cause the moisture to wick into the body of the piece, so that everything dries at the same rate. In general, be sure to complete each part of the process at the appropriate stage of dryness. Do not attempt to bring a piece that is too dry back to a workable moisture content.

Finish the Bottom: This is one of the most frequently neglected areas in ceramics. Whether a nonfunctional sculptural form or a functional vessel, a sloppily finished bottom or lower edge can ruin the appearance and feel of otherwise good work. In general, a sharp edge is a mistake, as the form seems to blend into or grow out of the surface on which it sits. Unless this is your intention, create a slight undercut at the base to create that all-important line of shadow that sets the piece off from the surface beneath.

Making Pinch Forms

No matter what one's intended goals or present skill level in ceramics, the pinch construction method is an excellent exercise and an exciting way to make small vessels. Whether you are handbuilding or working on the wheel, the actions of the hand in squeezing and manipulating the clay and the relationship between the inside and outside of the vessel are of critical importance. Pinch construction teaches sensitivity to wall thickness and the strength and resiliency of the clay. Through pinching, we become extremely sensitive to the use of touch rather than sight in determining and controlling ceramic form. With practice, pinch construction can become a viable method of creating small vessels very quickly without the imposed mechanical precision of the potter's wheel.

As you work through these instructions, refer to the accompanying series of images in **Fig. 2.2**. To begin, wedge a softball-size lump of clay thoroughly. Divide the clay into 2"-diameter balls, and loosely wrap all but one in plastic to protect from drying. Place a ball in your cupped hand and with the thumb of that hand, begin penetrating the center of the ball. With a rhythmic series of motions, alternate between pressing your thumb into the clay and rotating the ball around your thumb with the fingers of the other hand, keeping the ball resting in your cupped hand the whole time. Keep this up until you can feel the pressure of your thumb through the bottom of the ball, but stop before it actually breaks through the surface. You have now established what will be the center of the bottom of the pot. At this point, instead of pressing straight down into the lump, begin pressing the tip of your thumb to the side to widen the bottom of the pot, again alternating with rotating the pot (press, rotate, press, rotate, press, rotate, etc.). With your thumb bent, pressing only with the tip of the thumb, you will be spreading and thinning only the clay in the lower portion of the pot, without expanding the opening and the upper rim.

When you have made one pass around the bottom, or when the area you are pinching has reached a suitable thickness (no more than ¼"), begin moving up the wall, pinching in a very gradual spiral, thinning the wall as you go. The outside surface may develop shallow surface cracks, but these are not a problem as long as the clay doesn't get *too* dry while you are still working it. You can smooth these cracks with your fingernail or a rib, but, if left, these shallow cracks can form a very attractive surface texture not unlike aged leather. Deep cracks are another story, especially if they are forming in the rim. As you are expanding the pot and working your way up the walls, if the surface begins to crack badly or if the rim begins to crack *at all,* you must tend to it right away. Have a small container of slurry handy, and at the first indication of a bad surface crack or a rim crack, put a *very small* amount of slurry on the crack and work it back together with your finger or a modeling tool. Otherwise do not use *any* water on the surface of the pot while it is underway, as water will soften the clay and interfere with your progress.

As you work your way up the walls of the pot, the rim may inevitably expand more than you want. If this happens, cup your hand over the rim and gently squeeze, rotate, squeeze, rotate until you have reduced the rim to the desired

Figure 2.2
Pinch Construction

a. Begin pinch construction with a 2" diameter ball of clay.

b. Cradling and rotating the lump in one hand, penetrate it with your thumb.

c. Rotate continuously as you penetrate the lump.

d. Stop when your thumb pressure forms a dimple on the bottom.

e. Pinch to the side to begin forming the walls.

f. Rotate continuously, working up the walls.

g. Pinch to the final thickness and resolve the surface.

h. With a finger inside, smear the clay inwards to reduce the opening.

diameter. Another good method for reducing the rim diameter is to reverse the position of your fingers, with a finger on the inside under the rim and your thumb on the outside smearing the clay inwards towards the center of the opening. Rotate the pot continuously as you do this, and with practice you can close the rim to a very small opening, or even close it completely to create an enclosed form.

Finish the rim however you wish. Some pinch-potters like to leave a thicker rim, whereas others like to pinch the rim to a sharp edge. Some pinchers like to keep a symmetrical, even pot and/or rim; others prefer an asymmetrical pot and/or an uneven rim. Each to his or her own. If you want to have an even, circular opening, let the pot get leather-hard, and then trim the rim. If you are going to sand the pot when dry, wait until then to resolve the shape of the opening.

When the pot is completed, you of course have numerous options such as the application of tripod feet, a pedestal base, small hanging lugs, handles, or other appendages. If you wish to make spherical shapes, it is possible with a single lump, but you also may wish to pinch two hemispheres and join them when leather-hard. Pinch construction is only practical for vessels up to four or five inches in diameter, so the addition of ornamental or functional elements can greatly increase the visual impact.

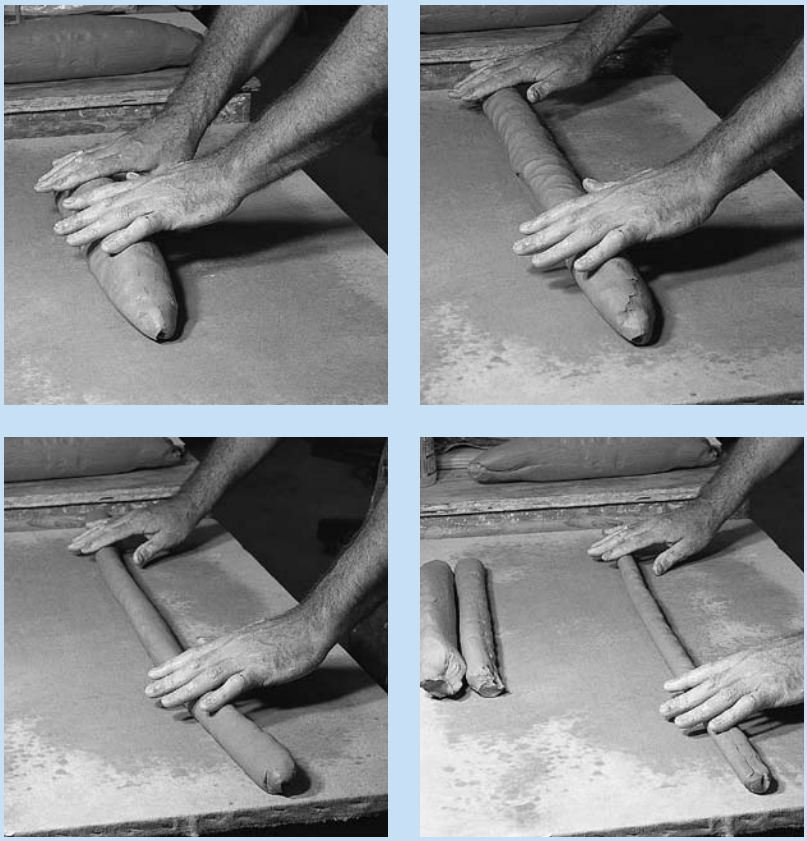
Coil Construction

Throughout history the prevalent handbuilding approach has always been the method known as coil construction. This is still the standard method in all tribal pottery traditions, such as those currently active in Africa and the Americas. We must avoid any assumption that coil construction is in any way inferior or primitive. The form and surface of a coil pot is controlled by the potter from start to finish without the influence of any mechanical devices, and the expressive and imaginative possibilities are endless. Even the most uniform and symmetrical coiled pot expresses the beautiful imperfection of humanity and the personality of the maker throughout its form. Altogether too often, these qualities are erased on wheel-thrown forms.

In general, a smooth-turning banding wheel offers tremendous advantages in most coil construction. If a kick wheel is available, it is great to be able to rotate the form with your feet while both hands are busy adding coils and smearing them together or in modifying the form.

Coil vessels are constructed by an additive process of building up the walls with long ropelike *coils* of clay (or other repeating modules, such

Figure 2.3 Rolling Coils for Construction



as small pancakes). Always start off with a good supply of well-wedged clay—keep your clay supply covered with plastic so it doesn't dry out while you are working. *This is critical,* as the coils should be very tacky when joined. You must make the choice of hand-rolled coils or, if the equipment is available, extruded coils. You can roll long, uniform coils very quickly by hand, without the mechanical precision and shape imposed by the extruder (**Fig.2.3**).

If you wish to make a flat-bottomed form, select an appropriate wooden board or bat and cover it with several thicknesses of newspaper. Make a flat slab of clay for the base—this need not be precisely rolled out—you can simply slap a lump of clay between your hands or pound it out on a flat surface to form a slab of an appropriate thickness for the intended form. Usually it's best to start with a slab larger than the desired base and trim it back *after* the lower portion of the pot is complete. This also ensures that you always begin coiling the walls *on top of the base,* rather than by laying the first coils next to it. This will give a much stronger joint between the slab base and the coiled walls (**Fig. 2.5**).

Coiling the Walls

Roll out (or extrude) a supply of coils. For the best coils, roll them on a well-moistened porous or canvas-covered table. When rolling coils, spread your fingers apart (see **Fig. 2.4**) and, as you roll forwards and backwards, quickly move your hands outwards towards the ends of the coil, bringing both hands back to the center, moving then outwards again, and repeating the process until you achieve the desired length and diameter of coil. Do not attempt to roll coils with stiff clay. Use soft clay, and make sure the rolling surface is well dampened. If the coil starts to go oval, purposefully restore it to round before continuing with your rolling. With a little practice, you will be able to roll uniform coils of whatever size you wish as quickly as they can be produced with an extruder.

For a small coil pot (8"–12" diameter) the coils should be ⅜" to 1" in diameter, depending on how aggressively you thin out the walls as you join the coils. For a larger coil pot, the coils can be ¾" to 1½" or more in diameter. There are several considerations here. Once you become accustomed to coil construction, you will be able to anticipate how much you thin the coils during the joining process. Some tribal potters use coils that are several inches thick, but during the joining process the wall is thinned to less than ⅜". Also, once the basic form is roughed out, you can come back and thin and form it with the paddle-and-anvil or rib-and-hand methods described below. A very thick cylindrical coil form may be thinned and shaped to a broad volumetric jar. It is essential that you anticipate these things in determining the size of coils to be used.

Don't roll out too many coils ahead of time, because if they stiffen up *at all* they will not join satisfactorily. Score and slurry the desired attachment point on your base slab, and press a single course of coils in place, working it well to force out excess slurry. As long as you are using coils of soft clay, you need not score and slurry further as long as you proceed with adding coils. If you leave the form for a period of time and the walls begin to stiffen at all, then you should score and slurry before adding the next coil.

When adding each successive coil, drape the coil from one hand so that the coil end lays on the vessel wall on the far side of the form. With your thumb on the inside and fingers on the outside, aggressively smear the coil downwards on the inside with the thumb and upwards on the outside with your fingers, as shown in **Fig. 2.4e**. Rotate the vessel (or move around it) and slowly lower the coil onto the wall, smearing it in place as you go. Some coilers prefer to apply single-level courses of coils one-by-one, whereas others tend to coil in a continuous slow spiral. It will greatly help in this process if your coil pot is sitting on a banding wheel or a kick-wheel. Tribal potters often build their coil pots on the ground or on a low pedestal and walk around the pot backwards as they add the coils and work the form. If you want the form to expand in size as the walls rise, you can reverse the smearing movements, smearing up on the inside and down on the outside on the side closest to you. With practice you can cause the diameter to increase or decrease at will by altering these movements. Do not worry about cosmetic surface during this process. If you are smearing aggressively, you will leave a rather

Figure 2.4
Coil Construction

a. Resuming coil construction on an in-progress vessel: Score and slurry the edge.

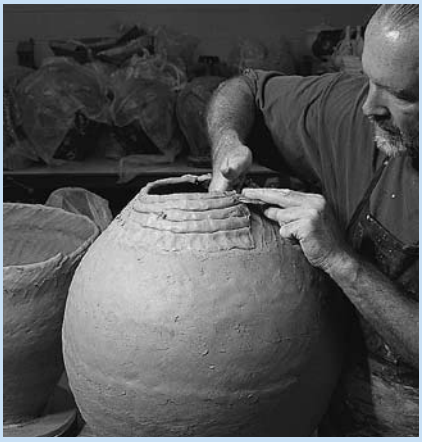
b. Apply a coil and gently paddle in place.

c. Smear the soft coil downwards inside and out over the stiffened edge.

d. As the next coil is lowered into place, smear it aggressively onto the previous one.

e. Add additional coils.

f. After every three or four courses, smear the coils together with diagonal strokes.



g. Smear additional coils inwards to reduce the opening.

h. To further close the rim opening, smear inwards with a rib.

ragged surface appearance, but this is evidence of well-joined coils. It is a simple matter to stop periodically and smear the surface smooth with your fingers or a rib.

Be careful when increasing or decreasing the diameter of your coil form to any radical degree, because the clay must have the structural integrity to support itself. Any time a clay wall veers away from the vertical, gravity will make it tend to lean or collapse. If you are contemplating a radical expansion or reduction in diameter, you must either allow the clay to harden sufficiently as you proceed, or you must provide a physical support for the clay.

If you leave your vessel for any time, always cover the top coil with damp paper towels to keep it moist and wrap the whole pot in plastic. When you resume work, if the top coil has stiffened at all, always score and slurry before proceeding, and paddle the first coil in place to ensure a good joint (see **Fig. 2.4b**). If there seems to be a lot of condensation inside the plastic in your studio environment, drape a cloth or sheets of newspaper over the form before covering it with plastic. This diffuses any moisture, which evaporates and recondenses where the plastic touches the form. Without this precaution, the condensation can concentrate and cause the clay form to collapse.

The possibilities of coil construction are unlimited, so almost any object or form can serve as inspiration. The ancient and tribal traditions of East Asian, Middle Eastern, Mediterranean, African, Peruvian, Meso-American, and Southwest Native American cultures all feature extraordinary design and technique in coil construction.

Closing the Mouth of a Coil Form

When you wish to narrow the neck or mouth of a coil vessel you can simply apply the coils to the inner surface of the rim and smear inwards on the outside of the vessel. As a refinement of this, support the inside of the rim with your fingers and smear inwards over the top surface of the rim with a rib, rotating the form continuously. As long as there is sufficient thickness in the rim, you can close the opening as much as you want by this method. If the rim is not thick enough to allow this, stop and add another coil, and then proceed with this method.

Slab Construction

Of the primary ceramic forming techniques, slab construction is the most modern. The technique of constructing with clay slabs is suitable for a wide variety of forms and is the ideal method for achieving flat-sided geometric and architectural forms. Historically, such forms were generally built by the coil method, and except for the remarkable slab-constructions of pre-Columbian Meso-America, there is little evidence worldwide of slab construction before the twentieth century.

There are two primary kinds of slab construction. With soft-slab construction, the slabs are manipulated while still soft to form curves and convolutions and formed or assembled immediately. With the stiff-slab method, the slabs are allowed to dry to leather-hard and are then cut to size and joined together.

Rolled Slabs and "Memory"

When clay is formed by application of pressure, the clay mass is compressed and the platelets are pushed around in currents, depending on the type and direction of pressure applied. The clay retains a memory of the compression and the currents, and it will shrink accordingly during the drying and firing. This is true with all forming methods, but it is rarely a problem. In slab construction, however, it must be taken seriously. When rolling slabs with a slabroller or rolling pin, if you roll only in one direction, you are setting up a grain structure similar to a wooden board. Both a board and a unidirectionally rolled slab have greater strength along the length than across the width, but will shrink more across the width than along the length. If you assemble a large slab form from these slabs, with the grain structures intersecting at angles, the piece will likely pull itself apart because of differential shrinkage in the drying and/or firing, especially with high-shrinkage claybodies, and in high-fired work. This is the most common problem area in slab construction. There are several solutions. If your slabroller has a wide enough bed, initially roll the slab thicker than you want, turn the slab 90 degrees, reset for a thinner roller height, and roll the slab again. With

hand-rolled slabs, simply change the rolling direction frequently. In either case, this will equalize the compression and currents, minimizing subsequent problems.

All slabs are subject to this problem, whether you are making slumped dinnerware, geometric boxes, or tiles. In all cases, memory of improper rolling can ruin the finished product.

Rolling Out Slabs

Commercial slabrollers are a wonderful innovation, and if your work calls for quantities of large uniform slabs, you should consider this major investment. If you do not have a commercial slabroller at your disposal you can easily roll out your slabs by hand with a rolling pin. As long as you don't need really huge slabs, this is not a disadvantage, as with practice you will be able to roll out slabs by hand almost as fast and just as uniform as with a slabroller. Even if you are using a slabroller, keep in mind also that the roller tends to stretch slabs only in the direction of travel. In order to avoid irregular shrinkage or serious warping, these slabs should really be aggressively hand-rolled on both sides at 90 degrees to the original direction of travel.

Rolling Slabs by Hand

Using an extra-long rolling pin with bearing-mounted handles, you can quickly roll out very large uniform slabs. If you need absolutely uniform thickness, make a series of pairs of long wooden slats in graduated thicknesses. With a set of slats laying across the table pointing away from you, with the clay between the two slats, and with the ends of the rolling pin resting on the two slats, you can roll slabs to an exact thickness. However, with practice you can roll slabs very uniformly without using the slats, and you are then able to make use of the full width of the rolling pin. In either case, be sure to turn the slab 90 degrees several times while rolling to equalize the compression.

Pound your clay into a rough slab, place it on an appropriate sheet of canvas (depending on the size you want) on a sturdy table, and start rolling it, changing directions frequently. Very soon the clay will stick to the canvas and won't expand any more. Lay another sheet of canvas on top, grab both sheets *and* the slab, using the broad surface of your fingers to minimize distortion of the slab, and flip the whole work over. Pull off the top (formerly bottom) sheet, pull the wrinkles out of the bottom sheet, turn the slab 90 degrees, and roll some more. Roll out from the center, and minimize pressure as you approach the outer edges, because it is very easy to get the slab very thin at this point. Roll along the edges as well, but when doing so, apply much more pressure against the end of the roller that is on the slab than that hanging over the edge. With practice, you will find that by rolling outwards from the center and along the edges in specific directions, you will be able to control the way the slab expands and thus control the finished shape. Continue to flip the slab, turn it 90 degrees, and reroll until you get the size, shape, and thickness you want. For greatest accuracy, measure the thickness in several places with a needle tool, just as you would measure the bottom of a pot.

Soft-Slab Construction

Soft-slab construction is the preferred method for a wide variety of vessel and sculptural approaches. It is ideal for any form that may be created by wrapping or draping slabs on slump or drape molds, or by simply manipulating a soft slab by hand. The following is a range of very simple projects that will serve as a good introduction to soft-slab construction and should provide a foundation for more ambitious soft-slab work.

Soft-Slab Cylinders

A wide variety of cylindrical or cone-shaped vessels may be made free-form out of soft slabs. Cups or mugs provide an excellent soft-slab project, and for these you should use slabs no more than ¼" thick. Cut a strip of slab as wide as the desired height of the cup and as long as the desired circumference. Score and slurry the ends of the strip and join them together to form a cylinder. You can either butt-join them (end to end) or you can overlap the ends. Set the cylinder on a flat piece of slab and, with your needle tool, mark lightly around the bottom circumference. Remove the cylinder and score and slurry inside this circle, then press the cylinder gently into place. Cut away the excess base slab, turn the cup over, and gently tap the bottom slab around the

edges to join it more firmly to the cylinder. Finish the cup however you wish. An alternate approach is to use bisque stamps or a sheet of textured material to create a pattern or texture in the flat slab before making it into a cup.

If you want uniform, evenly matching cups, you may wish to form your cups around a removable core such as an empty soda can. Cut a strip of ¼"-thick slab and wrap it around the soda can to determine the length of strip needed, then lay the strip back down on the table and cut it to length. Wrap an appropriate width and length of dry newspaper around the can (or other cylindrical form). Don't try to do this without the layer of dry newspaper, as you will be unable to slide the form out of the cylinder. Score and slurry the ends of the slab-strip, wrap it around the newspaper-covered can, and join the ends together. While the clay strip is still wrapped around the can, if you wish you may press bisque stamps or textured materials into the surface for decoration.

After you have joined the ends of the slab strip and added any additional stamped decoration, hold the cylinder carefully cradled in one hand, push out the can, and remove the newspaper. Proceed with adding the bottom as explained above.

Slump-Molds

In the current world of functional and decorative ceramics, slump- or drape-molded bowls and platters have become extremely popular. This method simply involves slumping a soft slab inside or over a mold. This is an excellent technique to use if consistency and uniformity of size and shape are desired, because all the vessels made from one mold can be very similar in size and shape. Professional potters make their molds out of plaster, bisque-fired clay, plywood, or foam insulating board, but almost anything of the desired shape will work as a mold. See **Figs. 2.5** and **2.6**.

You can make bowls and plates by simply slumping slabs inside an existing bowl or plate. Whenever the "mold" is a nonporous material, be sure to use several layers of newspaper strips beneath the slumped or draped clay to keep it from sticking to the mold. With slump molds made of plaster, bisque-fired clay, plywood, or foam board, no newspaper layer is required. Open-center molds made from plywood or foam insulating board have become very popular. When these are set on a flat table surface, clay slabs may be slumped into these forms to create flat-bottom plates and trays. Similarly, simple hump forms of plaster, wood, or foam board provide excellent hump molds, and when slabs are slumped facedown over such molds, the edge may be trimmed and a foot ring added immediately, minimizing later finishing.

For improvised slump-molds, shallow forms work best, where a single slab can usually be gently pressed into place. If you use a deep bowl as a mold you will have to apply the slab in several pieces, scoring, slurrying, and vigorously connecting the joints. After the bowl stiffens up a bit, invert it on a board, remove

Figure 2.5 Foam Slump Molds

a. Using a foam slump mold: Drape a slab over the mold.

b. Gently drop the mold repeatedly to settle the slab into the mold.

the mold or form, and use a wooden rib or modeling tool to smear together any wrinkles or gaps on the outside surface. Or, as a decorative option, make sure to smear the inside connections very well and leave the outside seams visible.

As mentioned, you can slump inside or outside of a mold or form. If you slump a very shallow platter or bowl over a convex form, you may be able to allow it to dry in place, and this has the added advantage of allowing you to add a raised foot-ring to the base if you wish. However, if you try to slump a deep-dished form on the outside surface of a rigid mold, you must remove it while still very damp, as any drying shrinkage could cause it to crack.

Making Tiles

There are some excellent books on the market about tile making, and this will be only a very short introduction to the subject. There are a number of ways to make tiles. The simplest is to roll out uniform slabs with a slabroller or by using a large rolling pin with a set of wooden slats as previously described. Let the slab stiffen to soft leather-hard, and then carefully cut your tiles using a razor knife and a straightedge, taking into consideration drying and firing shrinkage. Be sure to consult the section on "Rolled Slabs and Memory." If you

Figure 2.10
Foam Hump Molds

a. Using a foam hump mold: Place the mold on a board and drape the slab over it.

b. Gently drop the board repeatedly to settle the slab over the mold.

c. Score and slurry the back to accept a foot ring.

d. Place a coiled foot ring and gently paddle it level.

e. Clean off excess slurry with a damp sponge.

make tiles from improperly made slabs, the clay memory will cause them to warp during drying and/or firing.

Some production tile makers extrude their tiles from a pugmill, using a special extrusion die with a thin horizontal opening, producing a long continuous ribbon of clay that can be cut to any desired length. For small quantities of tiles, a similar extrusion die on a standard clay extruder works quite well.

Drying tiles is always a challenge, in order to produce perfectly flat tiles. One good approach is to sandwich the tiles between 24" squares of ½" drywall (sheetrock) until completely dry. For economical use of space, you can stack up to six layers of drywall and tiles. Obviously, this method works only for tiles that are of absolutely uniform thickness, are completely flat, or have only shallow incised or impressed decoration.

If the upper surface of the tile is not flat, or if the thicknesses are irregular, then this method will not work. In this case, the best solution is to simply make sure that the tiles are mobile (they are not stuck to the surface) and ensure that they dry slowly and evenly under plastic or in a controlled humidity environment like a damp/dry box.

Whatever method you use for making tiles, if your intention is to glaze them, all your efforts will be wasted unless you use a glaze that is a perfect match to the claybody. This is especially true in high-fired tiles, where the clay becomes very pyroplastic. If the firing shrinkage of the glaze is greater than the clay, the tile will become concave during the glaze firing. If the firing shrinkage of the glaze is less than the clay, the tile will become convex. You can do simple tests ahead of time to determine which glazes are appropriate for your tiles. When necessary, you can adjust the formula of a glaze to correct thermal expansion and make it fit your claybody. •

Throwing

Chapter 3

Of the various ceramic construction methods, throwing on the potter's wheel is the most common in Western, European-based culture. For producing large quantities of individually handmade functional wares it is the most efficient method. A traditional approach to throwing involves completion of the pot upon the wheel so that very little needs to be done afterwards to finish the form. This is especially true of certain jar, vase, bottle, and bowl forms. Even if a trimmed foot or a knob is needed, we often use the wheel for those tasks as well. It is a joy to use the wheel in this way, but consider also that the wheel is an extremely versatile tool for making component parts to be assembled off-wheel into vessels or sculpture. The wheel excels for making hemispheres, spheres, ovoids, flat disks, cylinders, cones, tubes, and myriad other shapes. All of these components can be assembled in an unlimited number of ways. If you do not explore these possibilities, you are missing one of the best things that the wheel can do.

Critical Points in Throwing

The following review is designed to help beginning clayworkers become familiar with the most important points in throwing. There are lots of steps to keep track of, and it will help greatly to go over this list frequently and commit it to memory.

Prepare Clay Properly. Wedge the clay thoroughly before using. This is especially important for wheel-thrown work. Don't waste time on clay that is too wet or too dry. If clay is too wet, let it sit out until stiffened adequately and rewedge, or wedge it on a dry plaster surface, or wedge in some dry material (although this decreases plasticity). Don't try to reuse clay from a previous pot that didn't work out—let it stiffen up and rewedge it before using again.

Prepare Plenty of Clay. With only one or two balls of clay in reserve, it is easy to develop an attitude of preciousness about each pot and a desperation to make each one work. Always prepare at least a dozen balls, and if a pot is not working, remove it immediately and start another one.

Clean and Dampen the Wheelhead. The ideal surface for receiving the clay is slightly damp but not wet. Use a rubber rib to squeegee off all remaining slurry from the previous pot, and if any surface moisture remains, remove it with an old towel (**Fig. 3.1**).

Slap Center. Before applying water, slap center a ball of properly prepared clay on the wheelhead or bat, and seal down the edges thoroughly (**Fig. 3.2**).

Avoid Touching the Clay When the Wheel Isn't Turning. Except for slap centering, always start the wheel before applying pressure, and always remove pressure before stopping the wheel.

Aggressive Commanding Approach. Clay appreciates a vigorous commanding approach with an economy of motion. Be clear about the specific reason for what- ever you do, and remember that with an aggressive, adventurous approach you will learn very quickly. Take risks.

Concentration of Pressure Points. All stages of manipulating the clay depend on concentration of pressure points. Concentrating force on a small area of the clay will give much greater control than broad application of pressure over a large area. Centering primarily involves pressure with the base of the right hand. Lifting the walls involves pressure with slightly bent fingertips rather than the flats of the fingers or the hand. Once the clay has taken the form of a basic vessel, you should never use the broad surface of your hand for any shaping task. If you want to smooth or flatten a broad area, use a rib.

Centering: Full Body Control. Centering and wheel wedging depend on full body control. The work is not done by your arm muscles, but rather by the full force of your upper torso when you roll your hips forward on the chair or bench (**Fig. 3.3**).

Work on the Right-Hand Side of the Wheel. After centering, always work at the right-hand side of the wheel where the clay is moving away from your hands (assuming you are throwing counterclockwise).

Work at the Correct Speed. Use full speed for centering, wheel wedging, and penetrating the lump of clay. Use medium speed for widening the bottom, lifting the walls, and finishing small vessels. Use slow speed for large vessels.

Action→Reaction. For every action there is a reaction. Keep in mind the consequences of every type of pressure that you apply to the clay, and, when lifting or shaping a vessel, apply corresponding pressure both inside and outside the form. Avoid expanding the diameter of a form without pressure from both sides, unless you are very sure of the anticipated outcome.

Lubrication. While throwing, keep the clay lubricated adequately at all times. Excess friction is your enemy. But remember that water is continuously absorbed into the clay, decreasing structural stability. As you practice throwing, try to work fast.

Remove Excess Water. Remove excess water whenever possible and as soon as possible. If you work

Figure 3.1 Throwing Position

Proper seating position when throwing.

slowly and a piece begins to soften, you may remove excess water and slurry with sponges and ribs. When you reach an approximation of the desired shape you may remove all excess water and do the final shaping with fingers, damp sponges, throwing stick (jug finger), or rubber, metal, or wooden ribs.

When Throwing, Use the Best Tool for the Job. Usually we throw with our fingers, but that is not always the best choice. When throwing porcelain, it often works very well to throw with a sponge on one side and a rubber or metal rib on the other, or even with two rubber or metal ribs, especially when making broad, voluminous forms. When making a tall form with a narrow rim, it makes sense to neck in the rim immediately upon achieving the desired height, and then use a jug-finger to broaden the body of the vessel.

Attention to Rims. When lifting walls, always stop just short of the rim. Compress rim regularly, and on cylinder-based forms keep rim diameter smaller than base diameter until wall height is established.

Synchronize Movements. When lifting or wheel wedging, synchronize the movement of your hands with the speed of the wheel so as not to leave deep spiral grooves or marks. Much of the problems in learning to throw are caused by lifting too fast in proportion to the speed of the wheel.

Cutting off the Pot and Finishing the Bottom. These can make or break an otherwise good pot. Always bevel the lower edge inwards before cutting the pot off the wheel. When cutting off pots, hold the cutoff wire very taut. When cutting off large flat shapes, always do so with the wheel turning to keep the cutoff wire from climbing up into the base of the pot. Trim or otherwise finish the bottom carefully, and make sure that there is a line of shadow around the base, separating it from the surface upon which it sits.

Skill Development with Cylinders

One of the best ways to develop your ability on the wheel is to throw lots of cylinders (**Fig. 3.4**). As you complete each one, cut it in half vertically with your cut-off wire to observe the cross-section profile. Don't try to do this with other shapes, because they will collapse as soon as you cut them, whereas half of a cylinder will still stand up. When you view the cut cylinder there are several important things to look for. First of all, a primary objective in throwing is to keep the outside profile and inside profile as similar as possible. In other words, if the walls are of uniform thickness, then the outside and inside will be very close to the same contour, whereas if the lower wall is very thick, the outside and inside will be very different in shape. Start off with a series of six or eight small cylinders, working up to about 4" or 5" in height. Try to achieve walls that are no more than ⅜" thick at the bottom and ¼" just below the rim, with a smoothly tapering wall in between. The bottom thickness is not so crucial, but remember that if you wish to trim the bottom it should be ⅜" to ½" or more thick (this will give you ample thickness for trimming a raised footring), and make sure that the bottom is flat and level, with a distinct rounded corner where the bottom ends and the wall begins. Later you may wish to throw forms with a curved bottom, but for skill development it really helps to become familiar with flat-bottom cylinders.

Figure 3.2 Slap Centering

Seal the lump down with the lower edge of your hands while the wheel is turning slowly.

When you cut each cylinder in half remember to carefully observe the uniformity of the walls, the smoothness and thickness of the bottom, and the uniformity and thickness of the rim. There should be very little variation in thickness of the walls from bottom to top, and the lower inside corner should be quite square, as indicated in **Fig. 3.5g**. With each successive cylinder, try to respond to the problems or faults in the previous ones, so that you are continuously experimenting and developing your technique.

If you find yourself frustrated with the ordinary cylinder, try doing timed cylinders. Sit down at the wheel with 20 or 30 small balls of clay, and have someone time you. This is a great exercise to do in a classroom situation. Start with five-minute cylinders, with 30 seconds in between to scrape off the previous one and put a new ball of clay on the wheel. When time is called, immediately stop the cylinder you are working on and scrape it off the wheel. After two or three of these, reduce the time to four minutes, then three, two, and finally one-minute cylinders. You will be absolutely amazed at the progress you can make through several of these sessions.

Throwing Bowls

Generally, most bowls are thrown on bats. In making bowls, penetrate the lump and widen the bottom just as in forming cylindrical forms, but there is no need to undercut when widening to keep the opening narrow. This will result in a wider, lower doughnut-stage (**Fig. 3.6**). As mentioned earlier, centrifugal force tends to force the clay outward from the center, and in making bowls you can take advantage of this force rather than having to counteract it. When lifting the walls, simply lift outward and allow the form to expand. Be especially careful to compress the rim with every lift, because the rapid expansion of the diameter can easily cause the rim to crack. If the rim does crack badly do not attempt to repair it. If there is sufficient clay below the crack you may cut away the damaged portion and proceed with what is left.

As a general rule, in the early stage of throwing any form it is wise to avoid radical horizontal orientation of the clay. In other words, in lifting and widening a bowl form do not widen the bottom too much initially so that it hangs over the foot. Instead, raise the walls so that

Figure 3.6 Throwing a Bowl

a. Throwing a bowl: Lift outwards.

b. Lift repeatedly, maintaining straight walls.

c. Trim away excess clay from base.

d. Resolve shape with rib, fingers, or sponge.

Figure 3.3 Centering

a. Centering and wheel wedging: Initially center the clay with firm side pressure.

b. Profile of properly centered lump.

c. Continue the side pressure while hinging hands together, causing clay to rise.

d. Cross section showing intermediate stage of wheel-wedging.

e. Raise the lump to a rounded peak.

f. Cross section showing maximum rise, with heel of thumb poised to press clay back down.

g. With continuing side pressure to prevent mushrooming, press clay back down.

h. Continue pressing downwards as lump widens.

i. Finalize centered form after repeated wheel-wedging.

Figure 3.4 Throwing

a. Basic throwing: After centering and wheel-wedging, form a dimple and apply water.

b. Penetrate the lump to create a V-shaped opening.

c. Widen the bottom using the "claw" motion, and compress the bottom.

d. Begin lifting the walls.

e. Maintain firm, even pressure and steady upwards movement.

f. Stop lifting just shy of the rim.

g. Compress the rim.

h. Begin second lift, pressing into the clay at the base.

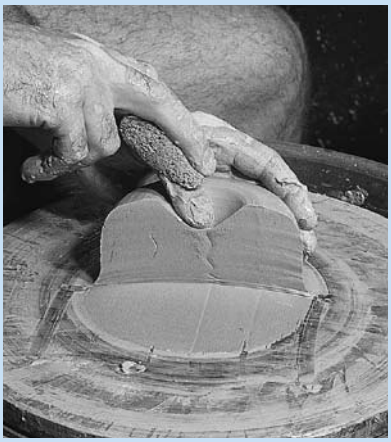
i. Continue lifting slowly and steadily up to the rim.

j. Repeat with the third lift.

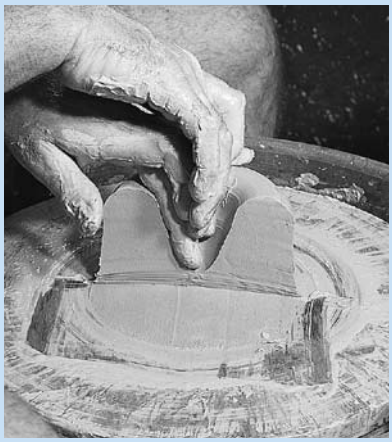
k. Begin shaping the vessel as you lift.

l. Think about the shape as you follow through.

Figure 3.5 Throwing Cross Sections



a. Cross sections of basic thrown form: Creating the dimple.



b. Penetrating the centered lump.

c. Widening the bottom.

d. The initial lift.

e. Stop just shy of the rim.

f. Second lift, pressing into the base.

g. Proper position during lifting, with inside fingers slightly ahead of outside fingers.

h. Final lift.

i. Resolving the shape.

they are straight or slightly convex (like the flare of a trumpet) rather than concave (like a hemisphere), and make sure that initially the walls flare out at no more than a 45° angle from the bottom. This is an extremely stable form that will allow you to achieve the desired height, diameter, and wall thickness.

Before proceeding further, always trim away excess clay from the outside base, (**Fig. 3.7**) because it will be very difficult to get access to this area when the curvature of the bowl is complete. If you are planning to trim the bowl, then you need only trim away excess clay and create a slight undercut to facilitate cutoff. If you are not planning to trim the bottom, you can undercut the edge with a wooden rib, applying gentle pressure with a sponge to the outside base, and create a very pleasing "foot."

For small bowls you may use your fingers, a sponge, or a curved rib to bring the walls out to the desired curvature. On large bowls it is a good idea to remove all slurry and water from the inside and outside surfaces before final shaping. You can accomplish this with a sharp-edged rib, like the standard stainless steel kidney-shaped rib. You can also squeeze all water out of two sponges and, with the wheel at slow-medium speed, use them to remove water and slurry from the surface. Either of these techniques will in effect "wring" water out of the clay, firming it up structurally so it is less likely to distort or collapse as you proceed.

Final shaping can be done with a variety of tools, depending on the shape you desire. For small bowls it is generally best to finish the shape with your fingers, but for larger bowls it usually works best to use a sponge or a curved rib to establish the inside profile. With the wheel rotating at low-medium speed (medium for a small bowl, low for a large one) work the fingers, sponge, or rib up from the bottom of the bowl, curving the clay outward a little with each pass from bottom to top. With your right hand, always follow the position of the rib with gentle sponge or finger pressure on the outside of the bowl. Repeat these passes until the bowl takes the desired shape. When using a rib to shape a bowl be sure to incline it so that it slides smoothly over the clay rather than scraping or cutting into it.

Drying Your Pots

It is possible to throw some shapes so that they have a perfectly acceptable base straight off the wheel, with very little finish work (**Fig. 3.7**). In most cases, however, you will need to trim the bottoms of your pots. After finishing the pots and placing them on ware boards you must anticipate when you will be able to work on them next and protect them appropriately from excessive drying. All trimming, attaching of handles, slip painting, applique work, and most decorative carving must be completed at the leather-hard stage, when the clay is stiff enough to handle but still damp.

Upon completing a pot, if you plan to trim it later that same day you may be able to leave it out in the open, depending on temperature, humidity, and air movement. If you won't be able to get back to it until the next day or later, you must cover it with plastic sheeting. The best material to use for this is a dry-cleaner bag or trash bag cut open to form a rectangular sheet. Wrap the plastic under the edges of the bat or ware board to prevent air currents from drying the pot. In very dry weather, especially in the winter when a forced-air heater is running, a pot may dry out in a day or two even when well wrapped. Check your pots frequently, and if they are drying too much, spray them lightly with a household spray bottle filled with water. If you anticipate having to leave them for several days and are concerned about excessive drying, you can drape dampened paper towels or rags over your pots or simply place several wads of wet paper towels on the ware board next to, but not touching, the pots and wrap them securely in plastic. Even in very dry weather, this should keep them at the leather-hard stage for at least a week.

Pay very close attention to the drying process. It is much easier to trim a pot or add handles with good results when you do it at the proper soft-to-medium leather-hard stage. Checking pots frequently to

monitor drying is simply part of the process. If a pot dries beyond proper trimming stage before you trim it, don't waste time on it—recycle it.

Finishing the Bottoms of Your Pots

Place the pot upside down in the center of the clean wheelhead. Start the wheel at slow speed, and hold one finger near the edge of the pot. Slowly move it in towards the pot until your finger touches the edge of the pot once on each rotation. This is the point where the pot is farthest off center. On the next rotation when the pot touches your finger, stop the wheel right at that point. Move the pot slightly towards the center of the wheel and repeat the process until the pot seems on center. When you get good at this, you may wish to try the tap-center method, where you gauge whether the pot is on center as described above, but then, without stopping the wheel, tap the form to move it further on center. Many professional potters use this method and can center a pot almost instantly. If you are not accustomed to it, it may seem all but impossible.

When the pot is centered, form four small lumps of clay, each the size of your thumb. While gently applying downwards pressure against the center of the bottom with one hand, press one lump in place, gently nestling the lump against the pot and applying primary force to smear the lump down against the wheelhead. Avoid applying excessive pressure against the pot. Rotate the wheel and pot 90°, press another lump in place, and so forth, until the four lumps are equally spaced around the pot. Maintain pressure with your hand against the center of the pot throughout this process, so that it doesn't shift on the wheelhead. For a low bowl, plate, or cup shape, very small lumps are adequate. For taller mug and jar shapes, larger lumps will be necessary. The lumps should never be pressed hard against the clay form, but they always must be smeared down thoroughly against the wheelhead.

When selecting trimming tools, you will have the greatest control with a very small trimming surface. The corners of a square-ended band-loop trimming tool give you the best option. Hold the handle of the tool in your right or left hand just as you would a pen or pencil, with the square end pointing down. Brace it firmly near the tip with the fingers of your other hand and with the cutting edge of one corner begin trimming the pot—remember concentration of pressure points.

Bring the wheel up to medium speed, start at the center, and trim a slow overlapping spiral all the way to the outer edge. If the bottom is at all irregular in height, then you will need to take repeated passes to trim it down to level. Hold the tool very firmly close to the tip with both hands during this process to overcome any irregularity in the bottom. If the clay is the proper medium leather-hard, then it will trim very easily and evenly, and the trimmings can be easily brushed off the surface with a soft brush or with your fingers. If the clay is too wet, the trimmings will ball up and stick to the surface and to the trimming tool. If the clay is too dry, it will feel very hard and scratchy when trimming. Do not continue with trimming if the clay is too wet or too dry.

After the bottom is completely level, begin trimming off all excess clay from the outer edges of the base. If the lower walls are thick you may trim some clay off them, but try not to rely on this any more than necessary. As much as possible, trim the excess clay off the lower walls while the pot is still wet on the wheel.

When trimming a leather-hard pot, remember that the objective is to make the outside profile (except for the foot ring) as much as possible like the inside profile, and trimming excess wall thickness is perfectly acceptable. Use the flat cutting edge to refine the trimmed area and to blend it into the untrimmed part of the wall. Use the curved end of a trimming tool to trim any convex areas.

If the bottom of the pot was quite thin to begin with, you may not be able to trim a raised foot ring, in which case the trimming process is finished at this point. If you really want to find out how good a job you're doing, you may have to sacrifice a few trimmed pots by cutting or breaking them in half to observe the cross-section profile of the trimmed bottom.

If there is enough thickness to trim a raised foot ring, after you have leveled the bottom and trimmed off any excess clay from outer edges and lower walls, examine the profile of the pot and decide what kind of foot ring you want. In some cases

the foot ring might be right up against the base of the wall, but more often it is recessed back beneath the base of the wall, as on Japanese tea bowls. On the one hand, a wide foot ring gives more stability, which may be desirable in a coffee cup or pitcher. On the other hand, a narrow foot ring, set back beneath the lower edge, elevates the pot from the table surface, which can be extremely important in the overall design. If you decide on a recessed foot ring, trim the lower corner of the pot inwards to where you want the foot ring to start, and try to get the outer shape as close as possible to the inner shape, so that the wall is a uniform thickness down the side and inwards towards the foot ring. After the outer edge of the foot ring is established, take another pass starting from the center of the bottom, stopping in time to leave a ⅜"-wide foot ring. Tap on the center with your fingertip. If it makes a dull click, then there is still plenty of thickness, and you may take several more passes across the bottom inside the foot ring. Tap the center of the bottom between each pass, and as soon as you begin to detect a hollow, drumlike sound, stop trimming, as this indicates that the bottom is quite thin. Be sure to trim any sharp corners from the foot ring.

Some potters trim without the use of clay lumps to hold the pot in place. If you wet the wheelhead slightly, the pot will stick to it, and with slight pressure against the bottom center of the pot with one finger, you can trim very effectively without attachment wads. As an alternative, you can throw a cookie of clay on the wheelhead, remove all moisture with your metal rib, and place the pots upside down on this surface to trim them. In either case, some potters like to put a small metal disk, like a jar lid or a bottle cap, in the center of the pot for the finger to rest against to hold the pot down to the wheel. With practice, this system can be extremely quick and efficient. •

Figure 3.7 Trimming Excess Clay

a. Trimming excess clay away from base of finished pot: Slice into the clay with a wooden knife.

b. Dribble water along the knife to feed it into the cut.

c. Slice horizontally under the waste flange with the wooden knife.

d. Stop the wheel, cut through the waste flange, and remove it from the pot.

Surface Decoration on Greenware

Chapter 4

There are a multitude of surface decorating options available at many stages during the ceramic process. This chapter explores a wide range of surface decoration possibilities on damp or dry greenware. The first category covers methods where clay is moved around on the surface. These include impressed, additive, and subtractive decoration.

Decorative Effects During Forming

It is frequently possible to create interesting pattern and surface effects during the process of building and shaping a vessel or sculpture. As you work the clay, constantly be aware of the marks your fingers and tools are making. In learning to draw we explore "marks on the ground" in order to discover all the mark-making possibilities in each medium. It is to your advantage to do the same with clay whenever possible.

Interesting coil patterns may be achieved during the coil construction process by applying coils, balls, or wads in any combination or orientation to give decorative surface variation. Join the coils well and smear together thoroughly on the inside.

Pinch/smear patterns may result from the way you manipulate the clay during the construction process, as when working coils together in coil construction.

Paddled facets may be formed in the clay by gently beating with a wooden paddle.

Colored clays may be laminated onto or pressed into the surface of the clay on any sort of vessel or sculpture.

Impressed Decoration

There is a range of techniques that involves pressing fingers, stamps, found materials, or tools into the clay, displacing clay without actually removing it from the surface.

Fingertips, fingernails, or knuckles may be used to impress simple grooves or patterns into the soft clay. In thrown or soft-slab forms, a fluted effect may be created by drawing fingers upwards inside and outside the form simultaneously, with a finger on the inside corresponding with the space between two fingers on the outside. Repeat this motion around the entire form.

Template ribs have a cut or carved profile that may be dragged across a wet clay surface to create effects very much like wooden molding, as shown in **Fig. 4.1**. They may also be used to create these effects on wheel-thrown pots, using plenty of water to lubricate the rib.

Modeling tools may be used to impress decorative marks or patterns without removing any clay.

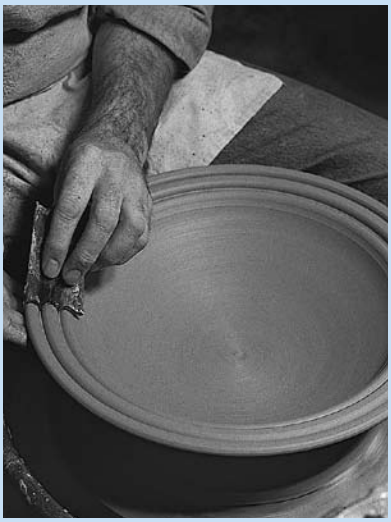
Combed effects may be accomplished by dragging a toothed tool across the surface (**Fig. 4.2**). Combing is usually done in wet clay, especially on pots on the wheel. Normal combing tools include a fork, toothed rib, notched modeling tool, or hair comb.

Stamps for impressing patterns or symbols into soft clay may be made from any rigid material, but durable porous materials work best. Plaster works, but there is always the risk of plaster contamination in the clay. The best stamps are made from clay and are bisque-fired, creating a porous surface that will not stick to damp clay. Stamps may be made by lifting a negative impression off of any raised-relief patterned or textured surface with a piece of soft clay or may be carved in hard leather-hard or bone-dry clay. When stamps are bone-dry or bisque-fired you may also take a second impression off of the stamp with another piece of clay, returning to the positive impression of the surface you started with, giving you both positive and negative stamps. However you make your stamps, attach a convenient handle to them before or after firing.

Bisque stamps work best on freshly worked clay that has had all surface slurry and moisture scraped away with a metal rib. Or, you may wish simply to set the forms aside to allow all surface moisture to evaporate before using stamps on the surface. Make sure to provide support behind the surface where you are using a stamp or roulette. If you use a bisque stamp repeatedly on a very wet clay surface it will soon absorb so much water that it will stick to the clay. When this happens, wash all the clay off the stamp and dry it thoroughly before using again.

Roulettes or coggles are pattern rollers used on wet or soft leather-hard clay forms, either static or turning on the potter's wheel. Roulettes may be made from any hard material, but the most effective rollers are made of clay and are bisque-fired. A circular disk of soft clay may be rolled on a patterned surface, or a leather-hard or bone-dry disk may be carved around the circumference. Rollers made of other material may be wrapped with string, rope, or

Figure 4.1 Using Template Rib



Using a template rib on a well-lubricated thrown form.

Figure 4.2 Combing Surface

Combing the surface with a fork.

other textured materials. Coggles should be made with a hole accurately formed through the center and after firing may be mounted on a wire or wooden axle and handle that allows them to turn smoothly.

Like bisque stamps, roulettes work best on soft clay, but you must scrape away all slurry or moisture, or let the form dry slightly before using the roulette (**Fig. 4.3**). Roulettes work especially well on thrown forms on the wheel. Be sure to provide backup pressure on the opposite side of the wall where you are using the roulette.

Textured paddles may be made from wood or bisque-fired clay. Or, a bisque-fired textured tile may be glued to a wooden paddle. A wood or clay paddle may be incised with a pattern of grooves or holes. A wood paddle may be wrapped with fabric, rope, cord, or wire. It may be covered with coarse sandpaper or other patterned material or with a glued-on layer of small pebbles or wood chips. In some cases you may wish to simply paddle the surface of a form with no backup support, while in other situations you may wish to use a rounded stone or a clay or wood "anvil" on the opposite side of the wall you are paddling.

Patterned or textured materials may be pressed into the clay—burlap, lace, string, cord, cheesecloth, wood grain, and plant materials such as leaves, ferns, twigs, or bark, or a piece of clay may be pressed against a patterned or textured material and then fired, making a permanent reusable stamp (see stamps).

Subtractive Methods

This category includes decorating methods that involve removing clay from the surface of a piece.

Carving may be done at any stage from soft to bone-dry. You will find that very different surface effects are produced depending on the degree of dryness of the clay. The quality of mark and surface will also depend on the kind of carving tool used. These might include a pointed razor knife, trimming tool, coring tool, fettling knife, or cheap wood-carving tools. Although carving tends to be most satisfying when the clay is medium to hard leather-hard, gestural "smeared" effects are possible with very soft clay, and very interesting stonelike effects can be attained by carving gritty claybodies when bone-dry. In the classic Chinese and Korean carved celadons, the carving was usually done in the very hard leather-hard or bone-dry stages.

Fluting can be accomplished by a number of means. One is described previously in the section on creating decorative surface effects with the fingers. For the most dramatic effects, clay is carved from the surface of a leather-hard pot, using a trimming tool or a fluting tool (**Fig. 4.4**).

Figure 4.3 Using a Roulette

a. Using a bisque roulette on a plate.

b. Using a bisque roulette on a rotating pot.

c. Using a wooden roulette.

Faceting may be done by paddling, as described previously. More often, facets are cut into the surface of a thicker-than-usual piece using a cutoff wire when the piece is still very soft, or when slightly stiffer using a fettling knife or cheese slicer, or when leather-hard using a Surform file or potato peeler.

Scraping can give a very interesting surface, especially on a gritty claybody. For a good stone-like effect, scrape the surface at the hard leather-hard stage with a sharp metal rib. Other scraping tools include wood and rubber ribs, spoons, seashells, household scrapers, gourd-ribs, and corncobs.

Figure 4.4 Using a Fluting Tool

Using a fluting tool on a soft leather-hard pot.

Piercing openings into a clay form may be done for a variety of reasons. The effect can be purely decorative on sculptural forms, or can be functional on incense-burners, candle lanterns, etc. Tools used in piercing include hole punchers, razor knives, or fettling knives. Piercing is normally done at the medium leather-hard stage, but may also be accomplished at the hard leather-hard or bone-dry stage with an ordinary drill bit.

Incising usually refers to shallow carved lines or patterns. As a general rule, always do incising with a fine-pointed carving tool, a dull-pointed dowel, or a dull pencil. Avoid incising with a very sharp pointed tool, because each incised line is a score-mark waiting to crack. Incised lines may be carved through a contrasting slip coating as in the sgraffito technique, or may be filled with slip as in the mishima technique.

Additive Methods

This category includes all methods where clay is added to the existing surface of a clay form. In general, you should score and slurry all add-ons, except in sprigging. If the add-on is soft plastic clay, score and slurry only the attachment point on the form. If the add-on is leather-hard, score and slurry both surfaces.

Appliqué generally refers to preformed flat pressed or carved clay decorations added onto the surface of a piece. Appliqués are often press molded ahead of time in plaster or bisqued-clay molds.

Sprigged decoration (sprigging) is done by pressing small coils and/or balls of clay onto the surface. A thin coat of slip (without scoring) is adequate when applying sprigging, but be sure to apply the slip a patch at a time so that it is still wet when the sprigging is pressed into place. Wonderful patterns like fish scales or fur may be created by sprigging on small pads or rolls of clay. Consider doing sprigging with a contrasting colored clay or with a layer of contrasting colored slip under the sprigging.

Modeled decoration includes a variety of methods where clay is added to the surface and then modeled with fingers or tools to create decorative elements. Coils may be added on and then smoothed into the surface to create raised ridges. Wads, strips, or pads of clay may be applied and formed with fingers or tools. For large molded sculptural add-ons, instead of modeling the form and then attaching it to the piece, considering attaching a large mass of clay to the piece, and then doing the modeling with both hands. When leather-hard, you can always carve through from the inside to remove extra clay. •

Glazes and Glazing

Chapter 5

Introduction to Glazing

As you begin each ceramic piece, and as you proceed through the stages of formation and decoration, consider all the possibilities of surface decoration, and make sure that each surface effect you employ enhances what is already there. Some people choose to carefully plan each piece completely from start to finish, whereas others prefer to allow the form and surface to evolve as the piece is constructed. Either approach is fine, as long as the results are satisfactory. As you resolve each piece, carefully consider what the final finish should be. If you are making functional vessels, a glazed surface is expected (at least inside). If you are making sculpture, glaze is just one option to be considered. In some cases, the unornamented clay or a chalky slip surface may be just what you want.

Glaze Color

Glaze color alone involves a range of variations including hue, value, intensity, and saturation. Hue is the actual color, such as red, blue, or orange. Value is the quality of light or dark. Intensity is the brightness of the hue—the degree to which it seems to jump off the surface. Saturation is the depth and richness of color, resulting from the concentration of pigment.

Glaze Transparency and Surface

Glazes are glass with various modifiers added to affect their behavior and appearance. Depending on the glaze materials and modifiers present, the glaze can be gloss, semigloss, semimatt, or matt. These are all qualities of reflectivity and visual/actual texture on the glaze surface, but variables in the glaze appearance also involve qualities within the glaze, including transparency/opacity, translucency, iridescence, thickness, and mobility (viscosity at maturation temperature). The most transparent glazes are invariably glossy, because anything other than a high-gloss surface interferes with transparency. However, high-gloss glazes can be a bit garish and tend

to show every surface flaw. Potters are often much happier with semigloss or semimatt glazes. Transparent semigloss glazes are very appropriate over slip-decorated surfaces, showing the variations of slip color while maintaining a softer surface quality.

Glaze-Firing Ranges

Glaze-firing temperatures are traditionally measured with pyrometric cones, and we often refer to glazes according to the pyrometric cone at which they mature.

Low-Fire: Throughout history worldwide, most ceramics have been low-fired, in the range from cone 012 (1623°F) to cone 02 (2048°F). Although the clay remains porous at low-fire temperatures, many ceramic colorants that volatilize or break down at higher temperatures are stable in low-fire, and available glazes offer virtually every color of the rainbow.

Mid-Range: Mid-range, extending from cone 4 (2167°F) to cone 7 (2264°F), has become an increasingly popular firing range. Mid-range firing can give a truly vitreous body, with a range of color almost as extensive as low-fire. For bright contemporary effects, mid-range gives the ideal combination of good durability and impermeability and broad color possibility.

High-Fire: High-fire, extending from cone 8 (2305°F) to cone 12 (2419°F), produces the most vitreous and durable wares. Accelerated glaze mobility in the superheated melt encourages mineral dispersion, desirable crystal formation, agglomeration of colloidal particles, active glaze–claybody interface, and other physical phenomena, which produce glaze strength and surface characteristic of natural stone, thus the term stoneware.

Glazing Methods

Wax resist and other resist compounds such as liquid latex are a very important accessory to successful glazing and surface decoration. There are a variety of water-emulsion wax resists available commercially. Some potters prefer hot paraffin or candle wax heated in an electric frying pan. All of them work, but some are better than others. Experiment. Commercial wax resist can be applied with a brush or sponge (the small triangular makeup sponges work well). For sponge application the consistency may be appropriate right from the jar, but generally a little water is added to give a good brushing consistency. Commercial wax resist is usually colorless and may be hard to see once it is applied to a surface. To remedy this, add a few drops of food coloring to the wax emulsion.

Apply wax to any surface that will be within ⅛" of the kiln shelf. With a trimmed foot, there should be at least ⅛" vertical clearance to allow the bottom to be glazed inside the foot. On any piece that sits directly on the kiln shelf without a raised foot, there should also be a narrow band of unglazed clay at the base of the walls. Of course, this all depends on the performance of the glaze at maturation temperature, and once you get to know your glaze you may be able to reduce the clearance. Many experienced potters apply wax only to the bottom of the piece, and, after glazing, remove any glaze residue from the waxed surface with a broad flat sponge. With moderate pressure, this will also remove a bit of glaze from the lower walls.

For application of wax emulsion to the foot of a piece, some forms can simply be dipped into a very shallow pool of resist in a wide pan. Another option is to place a flat sponge in a shallow pan of wax emulsion so that the surface of the sponge sticks up slightly above the liquid level, allowing the wax to soak into the sponge. The foot may then be rotated against this sponge to give an adequate coat of wax on the bottom and slightly up the wall. The softness and "tooth" of the sponge will determine the degree to which the lower wall of the form is coated.

It is important to realize that wax resist works only to restrict adherence of glaze, but it is never completely effective, so you must always go back and wipe any glaze accumulation off the waxed surface with a damp sponge or clean damp brush. Also, it is difficult or impossible to remove wax resist once applied, except by rebisque-firing the piece. When applying wax resist with a brush, never approach your work with an overloaded brush. Always drag the freshly dipped brush on the edge of the wax container to lighten the load a bit.

Contamination of Glazes

In any studio, especially in group studios, glaze contamination can

be a severe problem and must be consciously avoided by all involved. Never dip a still-wet glazed piece into another glaze. Never use a whisk, stir-stick, drill-mixer, or dipper in another glaze without washing it off thoroughly. Always label container lids, and put the appropriate lid back on each glaze. When you dip out a portion of glaze, be sure to return it to the appropriate container as soon as you are done with it. It is often impossible to identify a liquid glaze from appearance, and stray containers must then be thrown away. No one can afford such waste.

Glaze Consistency and Thickness of Application

There are no hard and fast rules here. The most common fault in glazing is excessive glaze thickness on the wares. Some glazes do require thick application, but many perform far better when applied thinly. If applied thickly, any glaze that is quite liquid at maturing temperature will run off the piece onto the kiln shelf and other wares. In this case, the piece is usually ruined, and the process of grinding glaze off the shelf is not a pleasant task. With a new glaze, always run tests to determine how the glaze performs at various thicknesses.

For an accurate gauge of proper glaze consistency, take a piece of scrap bisque, dip it into the glaze, shake it off, and as soon as the glaze is dry, scratch through the coating with a needle tool. You can then gauge the thickness of the coating, and thin the liquid glaze accordingly.

Many clear high-gloss glazes must be applied very thinly or they will turn milky. Because clear glazes are often applied over polychrome slip decoration, an excessively thick glaze coating would be a disaster. With any unfamiliar clear glaze, test various thicknesses of application before using it on work you really care about. Matt glazes often tend to be less runny, whereas gloss glazes are usually more mobile in the melt. These are not absolutes, however, and you must observe the performance of every glaze through previous examples or appropriate tests. Firing temperature is, of course, critical, as a tight glaze can often become much more mobile with only a single cone increase in temperature.

The wall-thickness of a piece will have a major effect on the thickness of glaze coating it accepts. Very thin pieces become saturated with water very quickly and will accept only a thin coat of glaze. Remember, it is the water soaking into the surface that causes the glaze to deposit properly on the surface. With very thin pieces, it is usually a good idea to glaze the inside, allow the piece to dry completely, and then glaze the outside.

Using Multiple Glazes

Whenever using multiple glazes on one piece, remember that any overlap may produce a logical blend of the two glazes or it may produce effects completely unlike either of the two glazes. In such cases it is best to do lots of experimentation on test pieces.

Multiple layers of different glazes can give very interesting effects, but this must be done very cautiously. When using multiple overlays of glazes, carefully consider possible shifting and running of the glaze accumulation.

Brushing Glazes

The practicality of brushing glazes onto the surface depends on the firing temperature and the viscosity of the maturing glaze. Any "tight" glaze that resists flowing may show all brushmarks, and therefore may not be suitable for brush application. In the case of overglaze decoration on top of a glaze that has been dipped, poured, or sprayed, brushmarks are often accepted as part of the process.

Most gloss raku glazes are fluid enough in the melt for all brushmarks to heal. Most satin or matt raku glazes are usually textural enough that brushmarks are not a concern, and in fact often add to the surface quality.

In general, brushes used for glaze application should have long, soft bristles, which give good reservoir capacity. Bisqued clay or a dry-glaze coating absorbs a great deal of water, and a brush with small reservoir capacity will not work unless streaky dry-brush effects are desired. When applied with a brush, glaze thickness and resulting visual effects tend to respond to the movement of the brush along with the surface contour and texture of the pot. To minimize brushmarks, soak the brush in water beforehand, shake out all water, load it completely with glaze, and flow the glaze evenly onto the surface with slow strokes. With a little practice, it is possible

to get a fairly smooth glaze coating with minimal brushmarks.

Dipping Glazes

Dipping and pouring are the most common glaze-application methods for functional pottery. It is essential that glazes be mixed to the right consistency for dipping, as discussed previously. Only you can determine the correct dipping consistency for your glazes. It is critically important to think about the amount of time an object is immersed in glaze. Usually a very quick dip and a quick, firm shake-off is adequate and will give an even glaze coating with minimal runs and drips. This is a matter of practice and conscious intent. Some glazes perform best with a slightly thicker coating, which may be achieved by holding the piece in the glaze slightly longer. Counting seconds will give you consistent results. Before you dip a piece, be sure you are holding it firmly enough to dip it and shake it off. Avoid holding forms by thin, weak sections. Also, keep in mind where the heaviest accumulation of glaze ends up, depending on how you shake off the excess glaze.

For small objects, a set of dipping tongs usually works well for overall glaze coating. The pointed prongs grip the piece firmly for dipping, but leave only very small marks in the glaze coating, which usually heal completely in the glaze melt.

For overall glazing on plates and bowls, grasp the piece with several fingers on opposite sides of the rim, and dip the whole piece into a wide tub or bowl of glaze. A large wok works extremely well for glazing plates and bowls. Special glazing tongs can be constructed to assist in this task.

With many pieces, the simplest means of getting an overall coating of a single glaze is to dip half of the piece and when dry, grasp that half to dip the other half. This works well even for functional work, depending on the glaze. With some glazes the overlap will be very obvious, and you must place the overlap with overall design in mind. If you dip quickly and shake excess glaze off quickly, you can usually minimize any visible overlap mark.

Interesting glaze results may often be achieved with overlapping coats of different glazes, although this technique requires considerable experimentation to avoid serious problems with running and crawling. Sometimes an overlapping combination of two glazes displays qualities of both glazes, whereas on other occasions the result is completely different from either glaze. This technique is especially advantageous when working with a limited number of glazes, because it offers many more possibilities. There are some simple guidelines to consider. Any time you double dip you are, of course, increasing glaze thickness, and therefore increasing risk of glaze problems such as running and crawling. If the first glaze has a fairly tenuous, powdery connection with the clay surface, dipping in a second glaze will often cause both glazes to peel and flake off the piece. When double dipping, always dip the second glaze after the first has dried completely.

On a vertical surface, until you know your glazes very well, it is wise to limit double dipping to the upper half of the piece and triple dipping to the rim.

Pouring Glazes

Pouring is very closely related to dipping and requires similar glaze consistency. Pouring may be used to glaze the inside of any vessel, to glaze the outside of a vessel too large for dipping, or to apply decoration over another glaze.

When planning to glaze the inside of a vessel by pouring, and the outside by dipping or pouring, always glaze the inside first. If you spill glaze over the unglazed outside it is easy to sponge off, whereas if the outside is already glazed you will have to live with it or clean the entire outside and start again. When glazing the inside, pour a cup or two of glaze (depending on the size of the vessel) in and quickly tilt vessel around to coat all surfaces, then pour excess glaze back into the bucket. With a little practice, you can pour the glaze in, slosh it around, wind up your hand and arm, and pour the glaze out while unwinding so as to glaze the entire inside and inner rim in one smooth movement.

Glaze Faults

No matter how careful and consistent we are in buying and storing materials, in mixing and applying glazes, and in loading, firing, and cooling kilns, periodic glaze problems are inevitable. Glaze materials change from one batch to the next, and we are all capable of human

error. It is important that we learn to recognize glaze faults and to deal with them in an appropriate manner to correct the problem.

Pitting and pinholing usually result from air escaping from the porous clay during the application of the glaze, and occasionally from outgassing of volatiles during the glaze firing. In many cases, pits and pinholes are already present in the raw, unfired glaze surface, and if left alone they may not heal in the firing. When you see pinholes in the dry glaze you can seal them over by rubbing gently with your fingertip. You can usually eliminate serious pinholing problems by bisque-firing slightly higher, by applying the glaze(s) slightly thinner, or by dipping wares in water 10 minutes before-glazing.

If the pinholes are not already visible in the dry glaze coating, they are usually due to outgassing of volatiles in the latter stages of the firing. A glaze that tends to pinhole during firing can often be cured with a simple oxidation soak at the end of the firing, which stabilizes outgassing and allows the glaze to heal. If none of these measures cure the problem, it is likely due to excessive viscosity at the maturation point, in which case a slight increase in flux content or a substitution of more powerful flux might help.

Crawling is one of the most destructive and troublesome glaze flaws and is characterized by the liquid glaze peeling or receding, leaving areas of dry clay surface. Crawling may be caused by a number of factors. If localized, especially if the glaze is quite thick, the cause is most likely a residue of grease or dust on the bisque surface before glazing, which can interrupt the glaze–clay interface. The solution is to keep unwanted grease, oil, or wax off the bisquewares and wash or brush off any dust or powdery residue of grinding and sanding. When applying wax resist, be especially careful to avoid getting waxy fingerprints on the wares. If you use a skin protectant before glazing, do so at least a half hour ahead of time, and then wash your hands with cold water and mild hand soap immediately before glazing.

Some coloring oxides, including iron oxide, cobalt carbonate, and rutile, are especially troublesome if used underglaze and will almost certainly result in bad crawling on flat areas.

Glazes applied excessively thick frequently crawl in the firing, especially if there are visible cracks in the raw glaze surface after it is dry. This is especially common in improper double- and triple-dipping of glazes (see the section on glaze thickness earlier in this chapter).

Any glaze that is excessively powdery will tend to develop a very weak, dry bond with the clay surface and may peel in the melt. In this case, you can add 2% bentonite or substitute ball clay for kaolin in the recipe or reformulate the recipe to increase clay content. •

Kilns and Firing

Chapter 6

All of us have in common the use of clay, usually the use of glazes, almost always the use of kilns. Ideally, our relationship with the kiln is that of friend and collaborator, with each firing bringing a sense of thrill and discovery. With proper knowledge and training, any good kiln becomes a benign collaborator.

General Kiln and Firing Practices

Electric Kilns

Electric kilns come in many sizes and configurations and are the most inexpensive commercially made kilns available. The installation of an electric kiln is very simple and inexpensive, making them very attractive for first studios and home studios. A broad range of ceramic processes and firing temperatures are suitable for the electric kiln, including ultra-low-fire luster and enamel firing, low-fire oxidation and raku, and mid-range and high-fire oxidation stoneware and porcelain. For those wanting an earthy, smoky effect, wares can be bisque-fired in an electric kiln and then bon-fired, raku-fired, or sawdust-smoked. There are also limited possibilities for sagger firing and reduction firing in electric kilns.

An electric kiln is simply a refractory box containing electric heating elements. The smallest electric test kilns and top-loaders operate on 110 volts, whereas most of the studio top-loaders, oval kilns, and smaller front-loaders require 220 volts. Larger commercial electric kilns generally operate on 208-volt three-phase power.

Because of the specialized features of the wiring and control systems and the nature of the element installation, it is normally impractical to consider building electric kilns.

Firing Logs

Keep complete written logs for all firings, including notations of any anomalies in kiln performance and firing outcomes. You will never regret this practice. For electric top-loaders the firing log may consist of only a few lines written in a notebook, but that is enough to tell you a great deal about the performance of your kiln over time. Firing logs should include

the time, date, intended maturation point (cone number), notation of which cones are in the kiln, a complete firing schedule including all changes and adjustments, comments on kiln condition and performance, and summary of firing outcomes.

Ventilation

In general, all firing processes produce toxic and/or corrosive fumes, which must be efficiently exhausted from the area. For any firing, make sure that the appropriate ventilation systems are fully operational during the firing. Even the simplest electric kiln gives off toxic fumes during firing. Unless such a kiln is installed in a separate shed with no one present during firing, an appropriate ventilation system is mandatory.

Don't Burn Yourself!

Kilns are often much hotter than they look, and even the outside surface can severely burn you. Never place hands or face close to an open peephole on a hot kiln. Even if there are no flames or visible fumes, the emerging gases may be hot enough to burn you. Use common sense when unloading a kiln. Think about where the wares may have remained insulated from cool air. Heat rises, so the wares at the bottom usually cool first. Also, wares in the center of a tight set can remain extremely hot when wares at the edges are quite cool. Wear gloves, and throw away any gloves with holes. Avoid wet gloves, because moisture can convert to steam instantaneously on contact with a hot surface, causing serious burns.

Opening Hot Kilns

Never begin opening a hot kiln while there is any red heat visible, and never open the kiln any appreciable amount without doing the newspaper-char-test to ensure that the temperature is lower than 451°F. Insert a newspaper twist in an upper peephole. If it chars or burns, the kiln is still above 451°F. If not, it is safe to open the kiln, although one should always be cautious in opening a kiln too abruptly, especially if the firing contains large vessels or sculpture.

Care of Refractory Surfaces

Softbrick interiors are crumbly and can be easily damaged by any abrasion. When lifting wares and shelves into or out of a kiln, brace yourself well and avoid any contact with the refractory surfaces. Attend to any degenerating refractory surfaces promptly.

Preparing and Loading Kilns

Always examine any kiln thoroughly before loading wares, and tend to any cleanup or small repairs. Make sure that all shelves, furniture, and refractory surfaces are in good shape.

Electric Kiln Preparations

Make sure that element grooves are free of any clay or glaze residue. Molten glaze is acidic and can erode through an electric element very quickly. Use a vacuum cleaner to remove any residue, and if necessary grind or chisel away any accumulations of glaze stuck to the refractory in the element grooves, and do suitable repairs.

In electric kilns equipped with the Dawson Kiln Sitter, make sure that the cone-support prongs are in good shape and free of crusty oxidation or the residue of previous cones. If not, install new prongs. They are very inexpensive, and they might save you the loss of a kiln load of wares and possibly even the kiln itself. If you ever must use a set of prongs that seem corroded, sand them off well with fine sandpaper and/or give them a coat of kiln wash.

Kiln Shelves and Furniture

Use appropriate kiln shelves rated for the particular type and temperature of firing. Top-loader electric kilns usually use ⅝"-thick (or up to 1"-thick, depending on the size of the shelf and the firing temperature) mullite or cordierite shelves, which are appropriate only for low and mid-range firing, and will warp if repeatedly subjected to high-fire temperatures.

Cleaning Shelves and Applying Shelf Wash

As you are loading any kiln, examine the shelves and furniture carefully. Loose, flaky shelf wash may be scraped off with a sturdy metal scraper or a heavy wire brush. Always wear safety glasses or a face shield and a good dust mask when scraping, brushing, or grinding shelves, and if possible do this work outdoors. If there is a serious accumulation of glaze residue it must be chipped or ground off before the

shelf or furniture is used. Minor glaze drips may be chipped off with a hammer and chisel. More serious glaze runs must be ground off. Never chip or grind shelves while they are resting on a concrete floor or any other hard surface—always place them on a cushioning bed of cloth or foam rubber. In a pinch, a bag of sand makes a great support. When chipping glaze accumulations with a chisel, never hold the chisel vertically against the shelf. Always sharpen the chisel so that only one edge is beveled, and hold the flat edge against the kiln shelf, so that the force is parallel to the shelf, against the glaze accumulation.

Loading Kilns

In general, kilns fire best with a fairly tight set. In electric kilns with a kiln sitter, be sure to place shelves and wares so that they will not interfere with the cone and cone holder on the inside of the kiln. On other kilns, don't place any shelf so that it interferes with the placement of cones in front of the peepholes, and don't ever allow wares or furniture to touch any thermocouple probes protruding into the kiln.

Selecting and Placing Kiln Furniture

As a general rule, kiln shelves should always rest on three posts, so they sit firmly in place with no wobbling. Fewer than three supports is obviously too precarious. With four posts, the shelf never sits squarely on all four points. If you occasionally find it necessary to use four posts because of a particular kiln-loading challenge, use wadding on at least one post so that the shelf sits level with no rocking.

In many kilns the bottom shelf is left in place from one firing to the next, unless it needs cleaning and rewashing. Normally the bottom shelf should be raised up at least 1" off the floor of the kiln in order to allow even circulation of heat and atmosphere. If the bottom shelf is already in place, make sure you know where the supports are located beneath the shelf, so that you can properly align successive tiers of posts.

To start out, always decide what height of wares (or piled combinations of greenware in bisque) you are going to load in the first layer, and select kiln posts of the appropriate height. Have a good assortment of kiln posts on hand. When properly cared for, they last forever, and you will be able to stack the set much more efficiently. If you have any scrap kiln shelf pieces around, consider cutting them into small blocks with a hammer and sharp brick-chisel. They make excellent shims for use with standard kiln posts. Coat all posts and shims with shelf wash on both contact surfaces.

Kiln posts come in sizes from 1" to 12" in 1" increments, and having an assortment of shims cut from shelves will give you considerably more flexibility in determining the height of each layer. Whenever possible, use single post sections to achieve the needed height, and when this is not possible, use the tallest post available with the shortest possible extension post or shim on top of it.

In kiln sets with multiple shelves side by side, whenever possible place the shelves at the same height and use common posting. This simply means that where two shelves meet, single posts are used to support both shelves. As mentioned, each shelf must have three support points, but wherever possible each post may support two adjacent shelves. By this method you can support two shelves with four posts. When considering the number of posts in a large kiln set, common posting will save a lot of posts. All commercial kiln posts are capable of supporting enormous amounts of weight, and as long as the posts and shelves are kept in good shape so that there is no wobbling, common posting is never a problem.

Always make sure that the surface of the shelf is smooth and level where the posts are to be placed, and make sure the ends of the posts are smooth and free of glaze residue. If needed, see the previous section on cleaning kiln shelves and furniture.

On each subsequent course of shelves, place the posts in *exactly* the same locations, so that loads are carried in a straight vertical line from top to bottom. If the bottom shelves have not been removed from the kiln, *make sure* that the stilts beneath them are in the same position as the ones you place above. *Deviations from this practice can be disastrous.*

Very tall posts tend to be unstable, and their use should be avoided whenever possible. Always try to place the tallest wares on the top layer of shelves, eliminating the need for such tall posting.

To those new to kiln loading, the arrangement of shelves, posts, and wares in a loaded kiln may seem precarious, but if properly done it is actually a very stable system. As long as you follow the above instructions and use quality shelves and posts, you should not hesitate to stack a dozen or more tiers of shelves when necessary.

Loading a Bisque-Firing

When loading a bisque fire, the wares can gently touch each other and may even rest inside and/or on top of each other, but use common sense—bone-dry greenware is *very fragile*. Use space as efficiently as possible, by placing small forms within large forms, and by stacking pieces carefully. Don't pile things so that too much pressure is applied against any one small area of a single piece, and do not pile up more than two or three bowls or plates on top of one another unless you are very sure of yourself. Place bowls or plates inside or on top of each other *only* if the bottom of one bowl or plate rests squarely on the bottom of the one below, without any pressure against the walls or rim. In other words, don't ever place one piece inside another if the walls of the upper piece are wedging inside the rim of the lower one.

Bowls or cups with matching rims may be stacked rim to rim, and this may be continued to considerable height. Or, a large diameter base may be placed on a matching rim beneath. Or, one pot can be placed rim-down, with another above it right side up.

Loading a Glaze-Firing

When loading normal electric oxidation glaze-firings, always leave at least ⅛" clearance between wares, from kiln walls, and from the shelf overhead. When glazing your wares, avoid having any glaze where it will be within ⅛" of the kiln shelf or on places where multiple parts touch, as with lids on covered jars or boxes. If you become very sure of your glazes, you can reduce this clearance. Lids should always be fired in place, because if fired separately they could warp and no longer fit, but there must be no trace of glaze on this contact surface.

When loading a glaze-firing in top-loader electrics, avoid placing the top shelf within six inches of the lid. Otherwise, the lid will draw off so much heat that the wares on the uppermost shelf will not reach temperature.

Remember that a full kiln fires well. If you must fire only a partial load, use taller kiln furniture than necessary, so that the set fills the kiln. This will give a more efficient, even firing. If you ever need to glaze-fire only a few things in an otherwise empty kiln, place three or four high-duty hard-brick around the wares. These will absorb a tremendous amount of heat, slowing down both the firing and the cooling ramps, so that the glaze matures properly, and pinholes and bubbles have a chance to heal.

Determining Appropriate Firing and Cooling Ramps

The rates at which a kiln is heated and cooled are referred to as the firing ramp and cooling ramp.

Bisque-Firing Ramps

The rate of temperature rise through the early stages of the firing is obviously a much greater concern in bisque firing. Even if your ware is bone dry, it still contains atmospheric humidity and chemically combined water, and must be heated slowly in the initial stages. Usually it is safest to simply warm the kiln overnight to drive off excess moisture. On a top-loader electric kiln this involves leaving the lid ajar with the peepholes out and the bottom element on low.

It is important to point out that if the wares are thin and quite dry, the preheat period may be reduced to as little as two to four hours, dependent on atmospheric humidity.

After an adequate preheat in a bisque-firing containing average size and thickness of wares, the initial heating ramp should not exceed 200°F per hour for the first two hours, and 300°F per hour for the next two hours. If the firing contains large work, this ramp should be extended to six hours. In either case, at that time red heat will have been achieved (approximately 1000°F) and the heat may be turned up fairly rapidly to bring the kiln up to bisque temperature. Depending on the individual kiln, the ramp rate at this stage is usually from 300°F to 400°F per hour. Keep in mind that the hotter the kiln, the more energy required to raise the temperature further. Thus even if you turn up the heat a great deal, the kiln may not climb more than 300 to 400 degrees per hour.

For the average top-loader electric, after an overnight preheat with the bottom element on low, normal protocol is to close the lid but leave the peepholes open, and turn all switches to low. After two hours, turn all switches to medium, and after another two hours, turn all switches to high. Depending on the age of the elements, and the condition of the wiring and the power supply, the kiln should shut off from three to eight hours after you turn it to high.

At temperatures below red heat it becomes difficult to measure the ramp unless the kiln is equipped with a pyrometer. In most kilns, with a little care and common sense we can control the heating ramp, but it is an excellent idea to fit any kiln with a pyrometer. It will provide you with peace of mind when monitoring the heating and cooling ramps.

It is critically important to avoid heating a bisque-firing too quickly, especially during the water-smoking period, as this can seriously limit outgassing, trapping carbon and other volatiles in the claybody, increasing chances of carbon and sulfur coring and later bloating and blistering. Excessively fast bisque-firing can also aggravate glaze problems such as crawling, peeling, pinholing, and blistering.

Glaze-Firing Ramps

When glaze-firing previously bisque-fired wares, there is little danger of wares exploding even if they are recently glazed (except in repeated loads in a previously heated raku kiln—allow at least 24 hours after glazing before placing wares in a preheated raku-firing). Bisque-fired wares are extremely thermal shock resistant and will withstand a very steep heating ramp. Just to make sure that residual moisture is driven off, one should normally maintain a gentle ramp for the first hour, but then the heat may be turned up quite quickly. On the standard top-loader electric, for a normal glaze-firing ramp, we would set the kiln on low for two hours, medium for two hours, and then turn to high. In an electric kiln with good elements, it is easy to fire much too quickly, which gives poor glaze results, and you must watch for this. A low-fire glaze-firing ramp should take at least five or six hours, with at least another two or three hours to reach mid-range or high-fire. Problems often arise in firing just a few pieces in an otherwise empty kiln. In this event, a good practice is to place three or four hardbrick in with the wares. They will soak up a tremendous amount of heat, slowing down both the heating and the cooling and allowing the glaze to mature and heal properly.

Cooling Ramps

In general practice, a kiln can be cooled at least as fast as it is heated. Excessively long cooling ramps accomplish nothing. When all red heat is gone you can determine when it is safe to open the door by carefully inserting a newspaper twist into the top peephole. If the newspaper chars or burns, the kiln is still above 451°F and cannot be opened. If it does not char, it is safe to begin opening the door. A bisque-firing containing average wares can be opened all the way at this time. A glaze-firing, or any firing containing large work, should be opened slowly over a period of an hour or two, as such pieces can crack from abrupt thermal shock even at such low temperatures.

The Degrees of Kiln Firing

Firing converts ceramic work from weak greenware into a strong, durable form. As the temperature in a kiln rises, many changes take place in the clay; and, if all goes well, you end up with a permanent result ready for using, showing or giving. Understanding what happens during the firing can help you avoid problems that may ruin hours of effort on your part. The chart on the next page provides highlights of what happens when firing your work. •

Kiln Firing Chart

Temperature C°	Temperature F°	Color	Cone (approx.)	Event
1400	2552	Brilliant white	14	End of porcelain range
			13	
			12	
1300	2372	White	11	End of stoneware range
			9	
		Yellow-white	7	
1200	2192		5½	End of stoneware range
		Yellow	4	
			2	Between 1100-1200°C, mullite and cristobalite (two types of silica) form when clay starts converting to glass. Clay and ceramic particles start to melt together and form crystals. These changes make the material shrink as it becomes more dense. Soaking (holding the end temperature) increases the amount of fused matter and the amount of chemical action between the fluxes and the more refractory materials.
1100	2012	Yellow-orange	1	
			04	
		Orange	05	
1000	1832		06	
			07	
		Red-orange	08	
900	1652		010	Between 800-900°C sintering begins. This is the stage where clay particles begin to cement themselves together to create a hard material called bisque.
			012	
		Cherry red	013	
800	1472		015	
			016	Between 300-800°C, the temperature must be raised steadily and ample air must be present to permit the complete burning of carbonaceous materials (impurities in the clay along with paper, wax, etc.). After 800°C, the clay surface will start to seal off, trapping unburned carbonaceous materials and sulfides, which could cause bloating and black coring.
		Dull red	017	
700	1292		018	
			019	
		Dark red	020	Quartz inversion occurs at 573°C. When clay is refired for a glaze firing, quartz crystals change from an alpha (α) crystal structure to a beta (β) crystal structure. The inversion is reversed on cooling. This conversion creates stresses in the clay so temperature increase and decrease must be slow to avoid cracking the work.
600	1112		021	
			022	
		Dull red glow		
500	932	Black		Between 480-700°C chemical water (referred to as "water smoke") is driven off.
400	752			
300	572			Upon cooling, cristobalite, a crystalline form of silica found in all clay bodies, shrinks suddenly at 220°C. Fast cooling at this temperature will cause ware to crack.
200	392			
100	212			Water boils and converts to steam. Trapped water will cause clay to explode so all water should be evaporated below 100°C. Begin a firing by keeping the kiln below 100°C until all water has evaporated.

Studio Safety

Chapter 7

Studio Safety Checklist

The following items should be of concern in all ceramics studios. Commercial and academic studios will always require other items and considerations according to local codes and practices.

- ✓ First aid kit containing general supplies
- ✓ Fire extinguisher mounted close to outside door, away from location of kilns
- ✓ Dust masks approved for ultrafine particulates
- ✓ Disposable rubber gloves for use while handling toxic materials
- ✓ Appropriate skin protectant/hand lotion for combatting dry skin
- ✓ Approved eye/face protection for use while grinding pot bottoms, cleaning kiln shelves, etc.
- ✓ Approved tinted safety glasses or face shield (shade 1.7 to 3.0) for looking into hot kilns
- ✓ Insulated heat-resistant gloves for checking/unloading kilns
- ✓ Appropriate ventilation for all kiln fumes and any other toxic fumes
- ✓ Approved clearance and heat protection around all kilns
- ✓ Good lighting in all work areas

Toxic and Hazardous Materials

It is essential that you are aware of all the possible toxicity hazards in the materials you use. For each individual ceramic material and refractory in your studio, you can contact the appropriate supplier and request the MSDS (materials safety data sheet). Suppliers are required by law to provide the MSDS upon request for the ceramic materials they sell you; these sheets will give detailed information about toxicity hazards. In addition, several good books about studio safety are available, and excellent articles addressing toxic materials can be found in contemporary ceramics magazines. Also, you will find a great deal of information on studio safety and toxic materials on Internet discussion groups such as Clayart. It is important to review the most current information.

With almost all ceramic raw materials there is very little danger of toxicity in skin contact. Some materials can cause some minor or serious problems as a result of skin contact and these materials should be handled with rubber gloves. It is important for all ceramic artists/artisans to realize that almost ALL ceramic raw materials are considered highly toxic when inhaled, and many when ingested. This is not a matter to be taken lightly, and it is essential that proper precautions be taken to ensure safe use of these materials, especially in mixing claybodies and glazes.

In all studio situations, toxic or hazardous materials should be very well marked and should be kept in locked cabinets or storerooms out of reach of children, pets, or any unauthorized personnel. Any food containers recycled for clay or glaze use should have all food labels completely removed.

Dust/Dirt Management

Dust control is perhaps the most pervasive problem in the ceramics studio, and yet it is really a simple thing to address with proper and consistent precautions. The amount of dust created in different circumstances is in proportion to the amount of dry powdered materials present, the particle size of the materials, the way the materials are handled, and the amount of air movement in the vicinity. The smaller the particle, the greater potential for airborne dust. And of course different materials have different levels of toxicity. The material most likely to be present as airborne dust is clay, and although the clay platelets themselves are not particularly toxic or hazardous, in most claybodies we find very hazardous materials, including silica and talc.

As a good general rule, you should avoid breathing dust of any kind in *any* circumstance. In other words, any situation that raises dust into the air should be avoided or should be approached only with appropriate dust protection. This is especially true indoors, because dust will settle on all surfaces and is easily raised into the air later on by any air movement. In normal studio practice, floors and tables should be kept free of dust and any clay scraps that will create dust when walked on or otherwise disturbed. Don't leave clay scraps on the floor. Don't leave ware boards where they might fall over and raise a cloud of dust. Confine all dust-producing processes to an appropriate ventilated area or spray booth, or take the work outside.

Floor and Surface Cleaning

In general, it is critically important never to sweep without using water or sweeping compound, no matter how efficient your dust mask, because as mentioned, when you raise dust into the air, it settles on everything and is easily disturbed by any studio activity.

For the very cleanest floors, after sweeping, spray down the floor very lightly with a hose or a garden sprayer, and use an industrial squeegee to localize the dirty water, making it a simple matter to pick it up with a mop or a large sponge. Long-handled squeegees in varying widths are available very inexpensively from janitorial suppliers.

Skin Care

For the most part, the materials we use in ceramics are relatively benign in contact with the skin, and the greatest problem is dryness. Problems with skin dryness are almost inevitable when working with wet clay, and minor rashes are common. If you experience these problems, use a good skin protectant before working with clay and a good skin moisturizer after. Many potters like the effects of plain aloe vera gel, available in most drug-

stores and health food stores. Glazing can be especially hard on the skin, and a good skin protectant will help, but be sure to apply it well in advance of handling any bisque-ware, and wipe your hands well directly before glazing, as any oily residue can interfere with glaze adhesion. Some people's skin is especially sensitive to glaze materials. If so, keep a package of disposable rubber gloves on hand.

Equipment Safety

All new ceramics equipment comes with safety guidelines, and many pieces of equipment come with safety guards or specific safety fittings and switches. Always observe the manufacturer's safety guide-lines, and never tamper with safety guards and safety fittings or switches.

Ventilation for Kilns

Make sure that all kilns are properly ventilated, and, when firing, ensure that appropriate exhaust fans are turned on. All kiln firings produce toxic fumes that *must* be vented to the outside. No unvented kiln should ever be located in a work space or anywhere in a residence. A by-product of all bisque-firings and (to a lesser degree) glaze-firings is sulfur dioxide, which is toxic and corrosive. Many metallic oxides release toxic fumes at high temperatures. Wax resist, although benign at lower temperatures, produces harmful fumes when it burns off the wares in the early stages of a glaze-firing. The organic vehicle used in commercial lusters and china paints releases toxic fumes during firing.

Safety with Kilns and Firing

It is normal to be curious about a kiln that is firing, and, with reasonable precautions, this is not a problem. The following guidelines should always apply to everyone in the vicinity of a kiln being fired.

All wiring for any electric kiln should be done strictly by local building and safety codes.

Make sure that all ventilation and safety equipment is in place and operating properly. See the previous section on kiln ventilation.

Make absolutely sure that there is adequate clearance between any kiln and adjacent flammable surfaces. Keep in mind that wood surfaces repeatedly exposed to heat may become progressively desiccated over time, increasing the chances of a fire. Always adhere to local fire codes and, when in doubt, install additional insulation or heat guards.

Never assume that a kiln is cold just because it is not on. Air convection over the surface may reduce radiated heat, and yet the surface may still be hot enough to burn you.

Whenever you must look into a hot kiln to check the atmosphere or cones, always wear tinted safety glasses or a tinted face shield. Make sure that the shade of the face shield or goggles is appropriate (shade 1.7 to 3.0) to protect your eyes from the extreme brightness. Goggles for gas welding are appropriate, whereas those for arc welding are too extreme. If you see spots before your eyes after turning away from the kiln, your eye protection is inadequate. •