CERAMICS AND METAL ART

by

MILTON G. Schoch

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTERS OF ARTS

MONTANA STATE UNIVERSITY
Bozeman, Montana

1977
MASTERS OF ARTS

HILTON G. SCHÖCH
The purpose of this paper is to develop two distinct reference sources for the ninth grade level in:

(1) Introductory Ceramics
(2) Introductory Metal Art

I intend to compile information to provide a resource for both student and teacher. This paper is based upon the expansion of curriculum standards and guidelines established for ceramics and crafts by the Half Hollow Hills School District, Melville, New York.

Each reference source will be divided into three sections, (1) history, (2) materials and equipment, and (3) processes and techniques. It will organize and communicate the basic knowledge necessary to successfully complete the requirements for my students in each curriculum.

The format for each area is essentially the same and understanding will be clearly derived from a justification for each of the three divisions.

HISTORY

For centuries students have learned from the experiences of their predecessors, from father to son or master to apprentice. The beginnings of knowledge are rooted, at least in part, in the experiences of others. The excitement of relating one's own experiences to those of the past, may motivate the student to fantasize their own progression into history. As well, the understanding of our contemporaries may illustrate the necessity for discipline, hard work and creative imagination. For the growth of creative thoughts is founded on the achievements of the past, as well as, the need and spirit to advance.

MATERIALS AND EQUIPMENT

The natural limitations of materials and equipment provide the guidelines for practical applications. This section includes a basic description of materials and equipment used in the classroom, as well as some that may be available in other situations. It will acquaint the students with names and uses of equipment and characteristics of materials. This will allow more time for individual assistance.
The descriptive analysis of techniques and processes will introduce established methods. It will relate to history and may motivate creative experimentation. These descriptions will also allow time for individualization and a basis for testing.

Vocabulary is essential for communication. Therefore, a glossary has been included to assist students in understanding terms.

The purpose of these reference sources is to provide a collection of information that is easily understood and effectively organized to answer questions of the inquiring mind. Therefore, the justification for this paper is to increase the quality and efficiency of my teaching. Although the following quote only refers to ceramics, it clearly illustrates a significant consideration of my teaching philosophy.

"In Childhood a natural process of rehearsal and growth through experience is constant, but educationalists do not take this sufficiently into account in the teaching of pottery. I often see electric kilns and power wheels installed in schools and clay, pigments and glazes bought ready made. This is beginning at the end, and is a loss of opportunity and a waste of money. Children and students learn far more by re-experiencing, as far as possible, the evolution of the potter's craft from its primitive origins. They enjoy finding and digging their own clay, building their own glazes as potters used to do before the machine age." ¹

I feel it is important to clarify that I have, and continue to emphasize a rudimentary knowledge of skills, equipment and concepts. Based on personal experience I have found this stimulates and encourages my students.

¹Bernard Leach, A Potter's Book (Great Britain, 1967), p. 27.
REFERENCE SOURCE

INTRODUCTORY CERAMICS
CERAMIC ART

Clay is one of the most abundant resources on earth, found in a variety of types and quantities. Due to the abundance of clay, it is a relatively inexpensive material that is used extensively in the commercial world.

Artistically, the expressive quality of clay is almost limitless. It is a pliable, responsive or "plastic," even senuous material that obeys the artist's touch with every push and pull. We will work with these qualities, inherent to ceramics, to develop a sense of tradition from what has been accomplished before, perception from what is about us today and projection for what is essentially to come.

CERAMIC DESIGN

Design, as defined by Webster is "a scheme, a purpose or intent; a sketch, an arrangement." It is all of those things; certainly it is the arrangement of details; it is sketching a plan and more. To the ceramist, it means form out of shapelessness.

It is often necessary to study some basic aspects of design as you begin work. At this level, emphasis will be placed on a few elements and principles of design. Although your idea may be altered and grow, the factors of design will organize and guide you toward success and completion.

Designing pottery must involve an individual decision-making process. In this class there will be a formal structure to design, because as beginning students, strong direction will provide the discipline necessary to achieve success. The ability to clearly understand and record your ideas will assist instructor and student alike, in refining your work so that it results in the best possible project. To help understand the elements and principles of design, a brief study based on Learning to See by Kurt Roland will be given at the beginning of this course.

In relationship to ceramics design, A Potter's Book, by Bernard Leach refers to the comparison of pottery to the human form and personality. This may be the reason why parts of pottery are referred to as the foot, neck, shoulder, belly, and lip. In the decision-making process you might consider relating the qualities of personality to your pots, such as strength, subtlety, nobility or warmth.¹

¹Leach, p. 19.
CERAMIC HISTORY

Ceramic history, as might be suspected, follows the change of early man from the nomadic hunter to the development of ancient cities. Due to the imperishable nature of fired clay, ceramic artifacts provide the most continuous record available of this gradual change.¹

The mysteries of life and death have always concerned man. His quest to appease these forces through magical symbols often buried with the dead, provide the basis of our knowledge concerning prehistoric man. The uncovering of these burial sites have produced relics, showing skills so advanced that one must wonder how far man has progressed in the years that followed.²

It is likely that man modeled forms from plastic clay, baking them in the sun, long before he discovered the hard and relatively permanent nature of fired clay. The development of pottery making is assumed to have come about after man began his settlement into a more or less permanent home. With a need to carry and store small seeds for planting, and water for drinking and irrigation, man's creative thoughts may have led him to line woven baskets with clay. It is suspected that when burning these baskets as waste or possibly the discovery of partially fired clay under camp fires, may have provided man with the knowledge that clay becomes harder and more serviceable when fired.³

As man searched for food and a favorable climate, he began settlements in various areas of the world. It is likely that ceramics developed independently throughout the world at various times.

It is intended that a very brief chronological listing will provide some indication of the various achievements in ceramics. Note that these findings of archeologists represent only what has been found to date.

5500 B.C. - Glazed green copper tiles from Egypt represent the first examples of glazed ware.

5000 B.C. - First slip decorated pottery in Harappa, India.

¹Glenn Nelson, Ceramics, p. 1.
²Ibid., p. 1.
³Ibid., p. 2.
4300 B.C. - Slip decoration in Egypt.

4000 B.C. - Pottery with a turned foot may indicate the use of the potter's wheel in Northern Iran.

3000 B.C. - Slip decoration common in China.


1100 B.C. - Widespread use of potter's wheel in "Shang" China. Also hard white clay body used as well as common red.

- Tin and lead glazes used in Assyria on colorful brick reliefs.

1000 B.C. - "Geometric" decoration in Mycenae (Southern Greece), up to the 5th century B.C. Greek ware is symbolized by changed decorative styles of banding with what was called Greek "varnish" (neither glaze or varnish actually).

- Etruscans of Central Italy influenced Egyptian and Syrian ware (architectural reliefs and temple decorative animal sculpture), black slip glaze like Greek black "varnish."

- Roman use of bisque molds possibly influenced by metal work.

300-250 B.C. - First glazes introduced in China from Middle East.

- Discovery of early banded ware in Mexico, Central and South America (like Neolithic Europe).

206-220 A.D. - Han dynasty in China, Confucius and Lao Tzu (began 500 B.C.) but influenced this time period's rituals; burial site relics indicated Han dynasty ceramics, also.

- Trade between China and Rome brought the first translucent porcelain to Middle East.

220-589 A.D. - "Three Kingdoms" and "Six Dynasty" in China, "Great Age of Ceramic Sculpture."

- Use of porcelain slip.

- Development of high-fire glaze in China.
618-907 A.D. - T'ang Dynasty in China, exquisitely refined sculptures of horses, warriors and ladies of the court.

- "Sang de boeuf," "oxblood" (copper red) and celadon (jade-like) yellow to green glazes.
- Improvements on porcelain clay body.
- Ceramics used for everyday life not for burial.
- Porcelain ware equaled importance of rare old bronzes and jade objects.
- Temmoku glaze (hare's fur).
- Hardness and integration of glaze and stoneware clay body.
- Influence on Japanese "Tea Ceremony" ware (Kenzan) and Korean (Mishina - refer to surface technique) developed from Sung.

1368-1644 A.D. - Renaissance in Italy, Italian potters influenced by Spanish (Hispano - Moresque).
- Lusterware, tin-lead glaze (Majolica). Pottery became a surface to paint on. Della-Robia, excellent stone carver, worked sculpturally in terra cotta with light, marble-like glaze.
- Ming Dynasty, stable times in China that were greatly influenced by Sung Dynasty. Ming Period (like Baroque in the West) was highly technical but over elaborate.
- Led by trade, Chinese ware came into vogue in Europe. Generally, quality is described as declining to imitative, over elaborate.
**SECTION II**

**MATERIALS AND EQUIPMENT**

**CLAY TYPES**

Clay as a material is perhaps best understood after analyzing its geological origins. The earth began as a molten mass that was eventually cooled by the condensation of the steaming vapors, as they rose resulting in a cooling precipitation. In a molten state, heavier materials such as metals sank to lower levels, leaving a relatively uniform crust of igneous rock. This rocky crust is composed mostly of silica, aluminum and the mineral, feldspar. It is the decomposition through weathering of this igneous rock that provides clay, although it took millions of years to produce the present deposits.¹

There are two major types of clay, primary (residual) and secondary (sedimentary). Each is formed by the disintegration of rock, but primary clay is deposited around the parent rock. The result is a relatively pure clay uncontaminated by other chemicals and minerals. Kaolin is usually made this way. Secondary clays, on the other hand, are formed by erosion and deposited principally by water in river banks, but occasionally winds and glaciers have scattered clay into a variety of locations. Secondary clays are almost always a combination of many different clays and impurities.²

As will be seen, the clay "body" best suited for studio pottery is a combination of clays and other chemicals and minerals. Combinations provide the best qualities of each clay for a variety of purposes.

Refractory clays, which contain a high percentage of alumina, silica and feldspar, are considered purer because they have few other chemicals or minerals. They require a higher firing temperature to vitrify, or make them hard and dense. Kaolins are a relatively scarce example of this high fire clay. They are of great value to the potter, for they are the source of whiteness in a clay body and ultimately refined and fired, become white, translucent porcelain. The drawbacks of kaolins are that they lack plasticity or that moldable, pliable quality necessary for hand forming. Therefore, small amounts of plastic secondary clay are usually added to correct these unwanted characteristics. One type of clay usually added to kaolin is ball clay. It is known for its relatively pure composition and extreme plasticity.³


²Ibid., pp. 17-18.

³Ibid., p. 18.
Fire clay is another example of a refractory clay, however, unlike kaolin, it contains a measurable amount of iron or iron-bearing minerals. It has great value to both studio potters and industry, because of its high heat resistance. Fire clay is used to make fire bricks for kilns, furnaces, boilers and smelting pots. Without those fire clay bricks, metallurgical industries such as steel and copper producers would not have high fire furnaces for smelting.  

Stoneware clays are plastic, refractory in nature, firing to a wide range of colors and textures. They are quite popular with potters, for wheel and hand building because of their color, texture and plasticity.

Earthenwares are the most abundant and least pure of all clays. They sinter (see glossary) at a lower temperature and are usually very plastic, even sticky in a natural state. They are commonly used to produce brick, drainage and roof tiles and other heavy clay products. They often contain large quantities of sand and alkaline salts that must be refined before use. Therefore, they are usually mixed with other clays. They frequently fire to a red, brown or black color due to the high percentage of iron.

CLAY STAGES

Clay goes through a series of stages or moisture contents. It is necessary to understand these stages to successfully complete the ceramics process.

First, the clay is "slaked" or soaked in water to moisten each plate shaped particle. This usually makes plates stick together and slide against each other which lends to plasticity, although particle size is the most significant factor in clay plasticity. During this stage, clay is referred to in its liquid form as slurry (see glossary).

When this slurry is poured into plaster drying bats, these large plaster "bowls" act as absorbant sponges, removing the excess water, which has coated and floated the clay particles in a suspension. When the excess water has been drawn off, the clay is referred to as "plastic" and is ready to use.

The atmosphere begins to act immediately on the remaining moisture, evaporating it relatively quickly. As the potter begins working with clay, forming and molding it, he must maintain the

4 Ibid., p. 19.
5 Ibid., p. 20.
moisture content in the atmosphere around the clay to keep the clay workable. As the moisture escapes, the particles of clay draw together or shrink. Becoming dryer, the bond between them is more fragile. At this intermediate stage, clay is leather hard, partly because the texture resembles that of leather. The piece is firm enough to be sealed together with parts of similar moisture content, and can be carved, incised or imprinted.

As the evaporation continues, care must be taken to dry clay slowly and evenly. For if the clay dries unevenly, warpage or cracking may occur, caused by uneven shrinking of clay particles.

When the clay is fired, the drying process is complete. Again, care must be taken to begin heating slowly or steam will develop within the body, causing it to burst. The next stage occurs about 650° F., when the chemically combined water begins to burn off. Once the temperature reaches 930° F., the clay is dehydrated and will no longer slake or disintegrate in water.6

Quartz inversion is another consideration in firing. The crystalline structure of silica, usually present in the form of flint, expands (1063° F.), changing from alpha to beta quartz. When cooled the crystals reverse this change and shrink to the original size. This is an important factor in firing for it also necessitates slow even heating and cooling to prevent damage to ware.7

As the temperature continues upward, oxidation takes place at about 1650° F, all of the organic materials will have burned out.8

Vitrification is the return to rock-like or glassification of clay. As the kiln temperature is further advanced beyond red heat, certain oxides and impurities within the clay sinter, forming glass beads which hold the clay particles together, giving it a hard durable bond. Clays vitrify at different temperatures depending upon the quantity of these oxides. Some red earthenwares with high iron content will sinter at 1835° F, while some of the purest kaolins will require 3275° F. Therefore, when the studio potter makes his clay body selection, he must consider carefully the purposes of the piece and equipment available.9

9Ibid., p. 15-16.
CLAY PREPARATION

Slip Bucket - A series of large containers used to store dry clay and broken greenware (unfired pottery), also used to slake or soak clay.

Drying Bat - Large bowl-shaped bat of plaster used to pour slip into for drying.

Blunger - Motorized mixer for "stirring" slip to make an even consistency.

Pug Mill - Auger-type clay processor used to mix and prepare clay.

Wedging Board - Flat, absorbant surface used to wedge clay on (plaster, wood, concrete).

CLAY CONSTRUCTION

Potter's Wheel

Randall wheel which is a large wheel with

(1) recessed "head" for holding throwing bat
(2) detachable aluminum splash pan for easy cleaning
(3) large, heavy fly wheel at base for longer turning time. Caution should be taken when operating, spinning of this concrete wheel can cause serious injury.
(4) electric motor switch pedal should not be used until fly wheel is "kick" started, to avoid excessive wear; high speed operation with motor power, slower speed maintained with foot power.

Shimpo Wheel

(1) smaller wheel with flat aluminum head, best used for throwing from the hump or for tall forms
(2) bats can be secured with "cooky" method (see glossary)
(3) you can stand to throw, with operation of the accelerator pedal, you may also maintain infinite speed control.
(4) removable plastic splash pan for easy cleaning
For the wheel, you should have this list of tools at your disposal:

1. **Fettling Knife** - sharp tapered blade used for cutting and drilling holes in leather-hard ware.

2. **Elephant's Ear Sponge** - soft textured sponge used to moisten clay while throwing.

3. **Needle Tool** - used to trim excess moist clay while throwing.

4. **Carving Loop Tool** - used to trim leather-hard pots on the wheel.

5. **Rib** - flat, thin metal or wood shape used to form and smooth forms on the wheel.

6. **Chamois** - strip of leather used to round and smooth lips on pottery during throwing.

7. **Boxwood Tools** - wooden tool with a variety of end shapes used to draw, carve and form.

8. **Calipers** - hinged aluminum or wood arms used to measure openings and lids for proper fit.

9. **Garrette** - wooden handled wire used to cut large pieces of clay or cut pots from hump or bat.

10. **Throwing Bat** - plaster, wood or masonite disc to throw clay clay on, it makes removal of pots from wheel easier and safer.

For hand building, these tools are provided to make construction easier:

1. **Rolling Pin** - used to flatten clay for small slabs.

2. **Guide Sticks** - used in conjunction with rolling pin to assure an evenness of slab production.

3. **Boxwood Tools and Carving Loop** - tools may be used, as in wheel work, to smooth, carve, draw and seal clay.

4. **Paddle** - large wooden stick used to mold the form of hand-built work.

5. **Plaster Molds** - varied in shape and size; they are used to press clay slabs and coils in or on to build beginning or basic forms.

6. **Slab Roller** - large rollers and canvas covered "bed" used to make large even slabs.
(7) Extruder - plunger type clay forming device which passes clay through a template in a variety of shapes in coils of clay.

Glazing

A series of covered plastic containers will be provided by students, as well as potter's wax (some types of liquid floor wax will suffice) which is used in wax resist.

Along with the above, the students will learn to use:

(1) Triple Beam Balance - weight measuring device, used in this case for glaze calculations.

(2) Ball Mill - motorized rollers and ceramic jars used to process and grind chemicals with smooth stones.

(3) Mortar and Pestle - alternative method of glaze grinding, porcelain "bowl" and grinding "post" are used to crush and blend chemicals.1

Kilns

They are essentially fire resistant structures to contain heat at a high temperature. The kiln is one of the most important pieces of equipment, the potter uses, for it provides a controlled "fire," to complete the ceramic process. There are three limitations that categorize kilns:

(1) Temperature: low-fire - below 2000° F
               high-fire - above 2000° F

(2) Types of Fuel: Electricity
               Natural Gas
               Bottled Gas
               Wood
               Oil
               Coal
               Combination of Fuel

(3) Construction: Up-draft
               Down-draft
               Single-chamber
               Multi-chamber 2

---

1All tools and materials used in the classroom will be explained by instructor at appropriate times with slides as reference.

2Franz Kriwanek, Keramos (Dubuque, Iowa, 1970), pp. 53-54.
Beginning students should be aware of some of the advantages and disadvantages of these different types of kilns. The major distinction is the atmosphere within the kiln during firing. Namely, oxidation which is usually the result of "clean" flame (balanced combination) or electric heat, the newest and safest of firing methods. Reduction firing is probably the most popular way of firing stoneware. With its essentially inefficient (high fuel, lower oxygen mixture) flame, introduces carbon into the kiln atmosphere. This carbon tends to take oxygen from the oxides present, affecting the clay body and coloration of glazes.

When considering kiln construction, many factors must be reviewed:

(1) Capacity - the size of the firing chamber and number of pieces to be fired.

(2) Availability of materials and expenses.

(3) Location and limitations of placement.

(4) Types of fuel available.

(5) Type of atmosphere desired.

Once these limitations have been outlined and satisfied, the ceramist begins construction and experimentation. The above descriptions provide a basis of technical knowledge, however, the factors of personal control and excitement are undoubtedly the major reasons for experimenting with kilns. For it is in this final regulating stage that the potter strives to assure the quality results of his or her efforts. The opening of the fired kiln is not unlike the opening of a wrapped present, especially when you are confident in the knowledge that the contents will please your eyes and ease your mind. The practical experience gained will provide students and instructor with knowledge more valued than from texts and reading.

The following is a list of kiln equipment, parts and materials:

(1) Electric Elements - coils of nichrome wire that provide heat from electrical resistance; adjusted by setting control panel knobs - low to high.

(2) Fire Box - space in flame producing kilns for combustion of fuel and prevention of flame impingement.

(3) Fire Brick - durable, dense, hard brick composed of refractory materials capable of withstanding high temperatures.

(4) Bag Wall - a protective wall of heavy fire brick on fire chamber side of the fire box; it protects the ware from the impingement of direct flames.
(5) Insulation Fire Brick - high quality light weight, porous fire bricks used for their efficient insulation. They are also desirable because they can be cut and shaped easily to conform to kiln design.

(6) Kiln Shelves - are shelf of sturdy, heat resistant material, made of silicon carbide or saggar clay used to stack ware in the kilns.

(7) Kiln Wash - the combination of flint and kaolin or alumina hydrate that is painted on kiln shelves and floor to protect them from sticking pottery and glaze drippings. It is applied on supporting surfaces before firing and will flake or scrape off after firing.

(8) Posts or Shelf Supports - made of refractory material; they support shelves for stacking. It should be noted that supports must be placed beneath each other to avoid warping kiln shelves during firing.

(9) Pyrometer - high temperature thermometer used to indicate various temperatures.

(10) Pyrometric Cones - small, tapered cones of specifically formulated clays, calibrated to melt at precise temperatures. They are used as a test or an alternative to the pyrometer. (It is suggested that they be used whenever possible.)

(11) Star or Tripod Spurs - small refractory supports for glazed ware; used to protect foot rings of pottery from sticking to supporting surfaces.

Amongst all the tools and equipment described, the most important tools ceramists have at their disposal are their hands, eyes and especially a creative imagination. These tools of nature have served man from the beginning as a versatile means of accomplishing his needs. In ceramics, as in all forms of art, the hand and eye construct the concepts of the mind into physical reality. The level of success is determined by the skill and proficiency with which the eyes and hands achieve the desires of the mind. This sensitivity and perception rarely come without experience, discipline and effort. For even the most elaborate studio will be unproductive without the ultimate cooperation of these three natural tools.3

3 It is necessary to clarify that electric kilns and possibly a pit kiln will be used in this course. Other types are presented with illustrating slides for reference.
SECTION III
PROCESSES AND TECHNIQUES

The proceeding portion of this resource has briefly introduced some historical and technical information that will assist beginning student to understand the natural characteristics of materials and equipment in the field of ceramics. The next section will describe methods of construction and surface treatment that will be used during this class. We will endeavor to develop with these techniques, a basic knowledge in the varied stages of the ceramic process.

FUNCTIONAL DESIGN SUGGESTIONS

It is usually necessary for the ceramist to be concerned with functional design, for during some stage of their development the inherent utilitarian aspect of ceramics becomes important. Very generally, some standards have been established to indicate technical quality or a mastery of skills:

(1) Thinness illustrates an economical use of clay and an ability to manipulate fragile construction, but should not unnecessarily limit form.

(2) The "lip" of a pot is a thickness of clay formed around the opening to prevent warpage and distortion. It also serves as a conclusion to design.

(3) The foot is also a design factor, indicating a beginning of the form and may give the form a "lift."

(4) The lid of a pot should finish the design, maintaining a relationship in form and visual flow of the contour. It should obviously fit well and remain in place when moved or tilted slightly.

(5) Handles are functionally meant to lift the piece or part of the piece, and should, therefore, be securely attached and feel comfortable to hold. As well, they may be used in a decorative sense to compliment the form.

(6) Spouts are intended for pouring. To provide the best functional design, they should pour well, free of splashing. This can be accomplished by "pulling" the lip slightly down and out to force the liquid to drip off the end.
In cookware, such as casseroles, canisters, mugs, teapots, etc., ease of cleaning will be facilitated by smooth surfaces and rounded seams.
There are three basic processes in handbuilding: (1) pinching, (2) coil, and (3) slab. Each has its advantages and disadvantages to be considered before trying to solve a problem in clay.

1. Pinch: This is probably the simplest method of moving clay. It is also the basis of all clay constructions and combinations. Pressure between the fingers and thumb can provide an even thickness and a variety of textural qualities of all well-crafted ceramics works. It is a method used most often for finishing touches, but can be used to make a simple form or vessel.

2. Coil: The coil method of clay construction is one of the most time consuming and most difficult to achieve a smooth look. It is, however, one of the best methods of accomplishing the intricate and complex forms possible on the potter's wheel. The control of the growth of the form is slow, allowing the most subtle changes in design, but also making it difficult to achieve a smooth graceful flow of form.

There is a method of speeding up the rough form of the coil-built pot; by using a large coil, wrapped continuously around upon itself. You can accomplish a ROUGH cylindrical form which can be "paddled" to a thin, even-walled pot (by using a heavy stick with a strong textured cloth attached, you can also give the pot an even patterned surface that will help hide the characteristic bumps and ridges of the coiled form). Smaller coils may be added to construct a more detailed spout, narrow neck or other more delicate additions. By placing coils one directly atop the other, you will make a cylinder; moving the coil inside the one beneath it will narrow the form and placement outside the one beneath it will open the form. The paddle can be used to texture the piece, a rounded, wooden tool can be used to polish or "burnish" the surface or merely by securely adhering the coils with slip you can compose an image or pattern with exposed coils.

3. Slab: The slab method of construction is the most unique. It results in the easiest most finished looking product with the use of guide sticks to gauge the wall thickness and seams that are easily hidden. This fast, simple process is done simply by rolling out a large mass of clay between two narrow sticks and then cutting the desired shapes from the slab. Seal the shapes together with slip and score at the edges to assure the sealing of the seam. The possibilities are limitless, from functional to sculptural. A textural pattern can be given to the surface by rolling the slab on a cloth, lace or plastic.
The construction of large pieces is possible when the clay is dried to a leather-hard state, which allows forms to be added. The use of molds will provide a limitless array of variations to clay forms.
CERAMICS CLASS THROWING PROCEDURES AND SUGGESTIONS

Steps:

(1) Clay preparation - wedge, then form a cone or ball shape.

(2) Wheel preparation - adjust seat, check tools and report any that may be missing, fill bucket with water.

(3) Bat - flat disc or slab made of plaster used to throw and work clay on. Wipe clean and slightly moisten the bottom of the cone of clay; firmly place, flat side down, onto bat and seal with fingers, to plaster, as close to center as possible.

(4) Centering - place hands in a firm cupped position on either side of the cone and correct position of cone to visual center. Wet both hands and clay with small sponge for lubrication; move wheel at a relatively high speed. Firmly press cupped hands into a down-and-in movement, hold tightly until cone spins true to center, without irregular wiggles. It may be necessary to lubricate occasionally.

(5) Opening - place thumbs together, one on top of the other and steadily press down on the top of the cone, use cupped hands on the outsides of the cone. Making a small well in the top center of the cone, fill with water. Drill three middle fingers into well straight down into the center. Use your left hand to support cone on the outside by cupping hand around the outside and spread thumb to the far right to form a guide channel for three middle fingers on the right hand.

(6) Making bottom - Place hands in the above position, making certain they are well lubricated, and slowly and carefully pull three middle fingers toward heel of the left hand supporter until shape of pot walls are straight and even in thickness (all steps described above are to be done with the wheel moving at top speeds).

(7) Throwing - slow wheel to 1/4 - 1/2 speed and place left hand inside right hand outside and touch thumbs, hands placed at three o'clock as if circle were a clock. Starting at the bottom of the pot gently press three middle fingers toward each other on either side of the wall, hold hands firmly and plant elbows in your legs, begin to raise both hands evenly up together pulling a ring of clay toward the top of the pot. Stop before reaching the lip and lubricate pot with water from small sponge. Begin again at the bottom.
until pot walls are no more than 1/4 inch in thickness. Practice until a perfect cylinder is mastered, then begin forming of the pot.

(8) Trimming - once the pot has dried to a leather-hard stage, it may be necessary to clean or trim the bottom of the pot. First, check the thickness of the bottom to gauge the depth of trimming, for your pot should be equal thickness throughout. Next, place the pot upside down on the head of your wheel to center the piece. Secure the pot with coils of plastic clay to the head and proceed to trim the bottom. Begin with the squared corner of the loop tool pressing firmly into the center and slowly drawing the tool toward the outside edge. This will create a spiraled trough which can be smoothed with the flat side of the tool. Be sure to leave a ring on the outside edge to form the foot. This ring will provide a "lift" to the design. When necessary, consider smoothing and trimming the excess clay from the sides of the pot.¹

¹All processes of hand forming covered here will be demonstrated by instructor.
GLAZE AND SURFACE DESIGN TECHNIQUES

The following is a list of surface designs that the class will experiment with:

1. Incising and Stamping - simply drawing or pressing relief designs into moist clay.

2. Engobes and Underglazes - a variety of colorants can be used to paint designs and images on moist or bisque fired ware. They will most often show through or affect the glaze applied over them, providing a variety of results from soft smooth color to clear distinct shapes.

3. Sgraffito - the use of a tool to scratch in designs in leather-hard clay, can produce a wide range of line qualities when scribed through contrasting color slip.

4. Mishima - the application of clays or slips into the scratches, will fill in the gouges, when excess is scraped off, the contrasting color of engobe and clay body provide a distinctive visual impact.

5. Wax Resist - painted over a base coat of glaze or slip will provide an interesting contrast when a second glaze is applied.

6. Over Glaze - an enamel like glaze surface can be applied to fired glaze ware to give a detailed color variation. A third firing of the low-fire enamels is necessary, but will not damage the existing glaze.

GLAZE APPLICATION TECHNIQUES

1. Glaze pouring - when a large surface is to be covered evenly, one of the most successful ways is to pour glaze. It is suggested that the inside of most pots be "poured" first, to facilitate handling when applying the outside coat.

2. Glaze dipping - when the piece is small enough or the glaze supply large enough, immersing the whole pot is another successful application technique.

3. Glaze painting - painting glazes on bisque ware is usually limited to small areas because the characteristic brush marks may cause uneven coating and an inconsistent surface.

---

2 These surface and glaze application techniques will be demonstrated by instructor.
GLAZE CALCULATIONS AND TESTING

Glaze, the glass-like coating applied to most pottery, provides a washable, water-proof coating that can be very colorful. The understanding of glazing is complex and technical, but it is one of the most important aspects of ceramics. Even the most exciting forms can be ruined by glaze errors or defects.

The predictability of glazes may be difficult at the beginning, even with the most precise preparations. However, with the technical advancements of recent times, we are far more certain of the results than our predecessors. When selecting a glaze, a few considerations are important:

1. Firing Range - the glaze and clay body must have compatible temperature ranges.
2. Surfaces - the three basic surfaces available in this class are gloss, semi-gloss and matte.
3. Opaque, translucent or clear.

After making these basic choices, refer to the test tiles, which have been calculated by previous experimentation. The necessity for testing will provide more assurance of your results and will develop your skills for testing other glazes. The process for testing should follow the format of steps outlined:

1. Cover work area with paper to facilitate clean up.
2. Check to make certain your triple beam balance is accurate.
3. Balance the beam with your clean dry bucket (without the lid) on the metal plate and record weight.
4. Set beam for 100 grams heavier than bucket weight. This 100 grams will account for the base glaze amount you will be testing with.
5. Balance the beam with the appropriate base glaze you have selected from the supply source. Then, remove the bucket which will now contain 100 grams of base glaze.
(6) Now multiply 100 grams of base glaze by the appropriate percentage of colorant. This information can be obtained from the reference table.

i.e. 100 grams - Rhodes #13 (base glaze)  
X .05  -  5% Red Iron Oxide (colorant)  
5.00 grams - the weight of the colorant to be added

(7) Balance the clean, dry lid of container on beam and record weight.

(8) Add the weight of the lid and the grams of colorant, then set beam at this figure.

(9) Now add appropriate colorant to lid until balanced.

(10) Remove lid containing correct amount of colorant.

(11) Pour colorant from the lid into the bucket containing 100 grams of base glaze.

(12) Stir the dry base glaze and colorant with a clean, dry spoon.

(13) Once mixed so that no variations are visible, begin adding water slowly.

(14) Mix thoroughly and check consistency with instructor.

(15) Carefully record formula on an index card and on your bisque fired, glaze test tile (be certain to use an underglaze pencil when marking tile, other materials will burn off in kiln).³

Once your test is completed, it will be fired. Review the results; you may want to adjust your formula and retest, being sure to record and file your changes to provide reference.

The combination of glazes in application often produces some beautiful results. You may wish to mix several tests and overlap portions of them to evaluate their combinations. Whatever your glaze surface treatment, usually the best results come from previous experimentation and accurate testing. You will undoubtedly be more pleased with your final product after completely evaluating the test conclusions.

³This process will be demonstrated by the instructor and followed step by step.
The following is a list of commonly used glaze chemicals in our classroom:

**Flint**

(1) Flint is the most commonly used source of silica in glazes.

(2) It is the glass-forming component.

(3) All glazes have to contain a sufficient quantity of silica to form the glassy part of the glaze. In matte glazes the silica content is smaller.

**Potash Feldspar**

(1) It is the most important high-fire flux. It introduces potassium, alumina and silica into a glaze.

(2) In low-fire glazes, used sparingly, it will promote mattes.

(3) The compound itself resembles a glaze because of its three components: the alkalies, potassium, sodium and calcium (fluxes); alumina; and silica. Feldspar will melt and form a white milky glaze by itself at temperatures over cone 2.

(4) It decreases fluidity in a glaze.

(5) It increases the mechanical strength of glazes making them more resistant to scratches.

**Whiting (calcium carbonate)**

(1) This remains readily in suspension and is an important component of glazes in all firing ranges.

(2) In low-fire glazes, it should be used in small quantities, but it becomes a strong flux at higher temperatures.

(3) In low-fire glazes it will promote opacity.

(4) When added in excess, it will promote matte surface textures through crystallization.

(5) It increases the tensile strength of glazes and makes them more resistant to acids.

**Clays (Kaolin, Ball Clay and Natural Clays)**

(1) Clays are used to introduce alumina and silica into glazes.
(2) Kaolins and the ball clays are white firing; they should be preferred in colorless glazes and glazes with brilliant colors.

(3) Natural clays will influence color developments because of the large amount of impurities, mostly in the form of iron in the clay.

(4) Clays act as flotation agents in the glaze slip; they aid in keeping other ingredients in suspension; ball clays are especially effective.

(5) Some natural glazes can be easily converted into dip-glazes, and many when fired above cone 8 form a glaze in themselves.

(6) The clay content in a glaze strengthens the glaze-coating it is fired, increasing the handling capability of the piece.

**Borax**

(1) Borax can be used to introduce sodiums and boric acid into glazes.

(2) It is a major low-fire flux for alkaline glazes.

(3) It is highly water-soluble; borax-containing glazes must be ground with mortar and pestle and used immediately.

(4) Generally, it brightens glazes. It is also valuable when brilliant hues of blue, blue-greens are desired.

(5) Small amounts can be added to glazes on all firing levels to soften their viscosity.

(6) An excess of borax in a glaze will cause it to pinhole and blister.

(7) It is very often used in combination with lead.

**Colemanite**

(1) It is a naturally mined mineral consisting of calcium and boron. It is useful to add boric acid to a glaze in a water-soluble form.

(2) It is a popular low-fire flux and renders glazes brilliantly glassy.
(3) When added in larger quantities, it promotes mottled effects.
(4) It aids the correction of crazing in glazes.
(5) It extends the firing range of most glazes by several cones.

Nepheline Syenite

(1) It is a feldspatic material containing more potassium and sodium than feldspar and causing it to fuse at lower temperatures.
(2) When substituted for feldspar, it lowers the maturing temperature or increases the fluidity of a glaze.

Dolomite

(1) It is a mineral found in nature which contains equal parts of calcium and magnesium. It is used to introduce magnesium into the glaze.
(2) It renders to glazes the buttery quality of magnesium glazes, which is considered its greatest asset.

Zinc Oxide

(1) Zinc is a powerful flux in the medium- and high-fire ranges. In low-fire glazes, it should be used sparingly.
(2) In low-fire glazes zinc aids the opacity without impairing their glossiness.
(3) It renders glazes viscose.
(4) It can be used to correct excessive flow of some glazes.
(5) It increases the strength and acid resistance of some glazes.
(6) If added excessively, it may result in dry and matte surface textures.

Tin Oxide (Stannic Oxide)

(1) It is the most effective of all opacifiers.
(2) From five to eight percent will make a glaze completely opaque.
(3) When added excessively, a dry and matte texture will result.

Rutile:

(1) It is an impure form of titanium oxide and contains larger percentages of iron oxide.

(2) It promotes opacity, a yellowish tone and mottled effects in glazes. 4

Chromic oxide (Cr₂O₃) and other chromium compounds are commonly used in glazes to produce green colors. Dichromates are preferred because of the greater amounts of chromium per weight. Care must be taken in the glaze composition for, when combined with tin a pink will result. Zinc will form a brown, and high-lead glazes may develop a yellow-lead chromate. Reducing conditions in the kiln will blacken the color. In fact, even adjacent tin-glazed and chrome-glazed pieces may affect each other in the kiln. Bright low-temperature reds (under cone 010) may be produced by chrome oxide in the high-lead and low-alumina glaze.

Cobalt oxide (CO₂O₃) is the major blue colorant. It is extremely strong and therefore, often fritted with alumina and lime or with lead for lower-fire underglaze colors. The frit allows a lighter and more even color dispersion. Color stains made of cobalt, alumina and zinc are uniform at all temperature ranges. Small amounts of cobalt in combination with MgO, SiO₂ and Fe₂O₃ will produce a variety of hues in the pink and lavender range.

Copper oxide is (1) cupric or black copper oxide (CuO) or (2) cuprous or red copper oxide (Cu₂O). Copper is one of the few colorants that does not change greatly under normal oxidizing conditions. Lead fluxes tend to produce a blackish green. When copper and tin are used with an alkaline flux, a turquoise will result. Potash will induce a yellowish green while zinc and copper with fluxes of sodium, potassium, and barium will tend to develop a blue tinge.

Iron oxides have three forms: (FeO) ferrous oxide, (Fe₂O₃) ferric oxide or hematite, and (Fe₃O₄) ferrous-ferric oxide or magnetite. Iron is the oxide most frequently used to produce tan or brown bodies and glazes. Were it not for its pronounced color, it would have a wide use as a flux. It is responsible for most of the low-firing characteristics and the red color of many earthenware clays. A pink stain can be made with a smaller amount of iron plus alumina, calcium and flint. When reduced in suitable glaze, iron will form grey-greens.

---

Manganese oxide (MnO₂) is used in ceramics as a colorant. It should not be used in concentrations over 5% to either body or glaze because blisters may develop. The usual colors produced are in the brown range. With cobalt, a black results; with the proper alkaline fluxes purple and dark reddish hues may develop. When fritted with alunina, a pink colorant will be formed.\footnote{Glenn C. Nelson, Ceramics, (U.S.A., 1966), pp. 208-209, 212, 214.}
GLOSSARY
1. Alumina (Al₂O₃) - A major ingredient found in all clays and glazes. It is the chief oxide in the neutral group (R₂O₃) and imparts greater strength and higher firing temperatures to the body and glaze. When added to a glaze, it will assist in the formation of mat textures.

2. Ash - generally, the ashes of trees, straw, leaves, and so forth. It is commonly used in the Far East to provide from 40 to 60 percent of high-temperature glaze ingredients. Depending upon the type, it will contain from 40 to 75 percent silica, from 5 to 15 percent alumina, and smaller amounts of iron, phosphorus, lime, potash, and magnesia.

3. Bag Wall - A baffle wall separating kiln chamber from combustion area.

4. Ball Clay - An extremely fine-grained plastic, sedimentary clay. Although ball clay contains considerable organic matter, it fires out white or near white in color. It is usually added to porcelain and whiteware bodies to increase plasticity.

5. Ball Mill - A porcelain jar filled with flint pebbles and rotated with either a wet or dry charge of chemicals. It is used to blend and to grind glaze and body ingredients.

6. Bat - A disc or slab of plaster of Paris on which pottery is formed or dried. It is also used to remove excess moisture from plastic clay.


8. Blunger - A mixing machine with revolving paddles used to prepare large quantities of clay slip or glazes.

9. Blisters - A glaze defect, apt to be caused by impurity in the body, or under firing of glaze.

10. Bone China - A hard translucent chinaware produced chiefly in England. The body contains a large amount of bone ash (calcium phosphate) which allows it to mature at cone 6 (2232° F). It is not very plastic and therefore difficult to form; it also tends to warp.

11. Bone Dry - As dry as atmospheric conditions will permit, (no artificial heating).

12. Casting (or Slip Casting) - A reproductive process of forming clay objects by pouring a clay slip into a hollow plaster mold and allowing it to remain long enough for a layer of clay to thicken on the mold wall. After hardening, the clay object is removed.
13. Center - To place a piece in such position on a wheel that its center axis is an exact extension of the wheel axis.

14. China - A loosely applied term referring to whiteware bodies fired at low porcelain temperatures. They are generally vitreous, with an absorbency of less than 2 percent, and may be translucent.

15. Clay - Basically, a decomposed granite-type rock. To be classed as a clay the decomposed rock must have fine particles so that it will be plastic. Clays should be free of vegetable matter but will often contain other impurities which affect their color and firing temperatures. They are classified into various types, such as ball clays, fire clays, and slip clays. Pure clay chemically is $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$.

16. Coiling - A hand method of forming pottery by building up the walls with rope-like rolls of clay and then smoothing over the joints.

17. Cookie Method - Method for stickling bat to wheel head. A thin slab of clay is thrown on the head and grooved with the fingers. Slightly moisten the clay slab and press bat firmly onto it to hold bat on center.

18. Crawling - Separation of the glaze surface, caused by too heavy application, which cracks upon drying, of from uneven contraction rates between glaze and body.

19. Crazing - An undesirable and excessive crackle in the glaze which penetrates through the glaze to the clay body. It should be remedied by adjusting the glaze or body composition to obtain a more uniform cooling and contraction rate.

20. Dipping - Glazing pottery by immersing it in a large pan or vat of glaze.

21. Dryfoot - To clean the bottom of a glazed piece before firing.

22. Dunting - Crackling of fired ware in a cooling kiln - the result of opening the flue and cooling too rapidly.

23. Earthenware - Low-fired pottery (under 2000°F), usually red or tan in color with an absorbency of from 5 to 20 percent.

24. Engobe - A prepared slip which is half way between a glaze and a clay; contains clay, feldspar, flint, a flux, plus colorants.

25. Fire Box - Combustion chamber of a gas, oil, or wood-fired kiln, usually directly below the kiln chamber.

26. Fireclay - A clay having a slightly higher percentage of fluxes than pure clay (kaolin). It fires tan or gray in color and is used in the manufacture of refractory materials, such as bricks,
nuffles, and so forth for industrial glass and steel furnaces. It is often quite plastic and may be used by the studio potter as an ingredient of stoneware-type bodies.

27. Flues - Passageways around the kiln chamber through which the heating gases pass from the fire box to the chimney.

28. Flux - Lowest-melting compound in a glaze such as lead, borax, soda ash, or lime and including the potash or soda contained in the feldspar. The flux combines easily with silica and thereby helps break the higher-melting alumina-silica compounds eventually to form a glass.

29. Foot - The ringlike base of a ceramic piece, usually heavier than the surrounding body.

30. Frit - A partial or complete glaze which is melted and then reground for the purpose of eliminating the toxic effects of lead or the solubility of borax, soda ash, and so forth.

31. Glaze - A liquid suspension of finely ground minerals which is applied by brushing, pouring, or spraying on the surface of bisque-fired ceramic ware. After drying the ware is fired to the temperature at which the glaze ingredients will melt together to form a glassy surface coating.

32. Greenware - Pottery which has not been bisque fired.

33. Grog - Hard fired clay which has been crushed or ground to various particle sizes. It is used to reduce shrinkage in such ceramic products as sculpture and architectural terra cotta tiles, which, because of their thickness, have drying and shrinkage problems. From 20 to 40 percent grog may be used depending upon the amount of detail desired and whether the pieces are free standing or pressed in molds.

34. Incise - A tool technique for decorating pottery, removing channels of clay from the surface, somewhat as engraving is done, and generally done freehand.


36. Kiln Furniture - Refractory shelves and posts upon which ceramic ware is placed while being fired in the kiln.

37. Kiln Wash - A protective coating of refractory materials applied to the surface of the shelves and the kiln floor to prevent excess glaze from fusing the ware tight. An inexpensive and effective wash may be made from equal parts of flint and kaolin.
38. Lead - White lead (basic lead carbonate, \(2PbCO_3 \cdot Pb(OH)_2\)), red lead (\(Pb_2O_4\)), and galena (lead sulphide, \(PbS\)) are among the most common low-fired fluxes.

39. Leather Hard - The condition of the raw ware when most of the moisture has left the body but when it is still soft enough to be carved or burnished easily.

40. Mat Glaze - A dull-surfaced glaze with no gloss but pleasant to the touch, not to be confused with an incompletely fired glaze. Mat surfaces may be developed by the addition of barium carbonate, or alumina, and a slow cooling cycle.

41. Molds - A form or box, usually made of plaster of Paris, containing a hollow negative shape. The positive form is made by pouring either wet plaster or slip into this hollow.

42. Overglaze - Decoration applied with overglaze colors, either on the raw glaze or on the glazed and fired ware. In the latter case, the firing of the overglazed ware is at a lower temperature than the glaze fire.

43. Oxidizing Fire - A fire during which the kiln chamber retains an ample supply of oxygen. This means that the combustion in the fire box must be perfectly adjusted. An electric kiln always gives an oxidizing fire.

44. Plasticity - The quality of clay which allows it to be manipulated and still maintain its shape without cracking or sagging.

45. Porcelain (Chinese) - A hard, nonabsorbent clay body, white or gray in color, which rings when struck.

46. Porcelain (hard) - A hard, nonabsorbent clay body which is white and translucent. In both types of hard porcelain the bisque is low fired and the glaze is very high (generally cone 14-16).

47. Pug Mill - A machine for mixing plastic clay.

48. Pyrometer - An instrument for measuring heat at high temperatures. It consists of a calibrated dial connected to wires made of two different alloys, the welded tips of which protrude into the kiln chamber. When heated, these tips set up a minute electrical current which registers on the indicating dial.

49. Pyrometric Cone - Small triangular cones (1 1/8 and 2 5/8 inches in height) made of ceramic materials which are compounded to bend and melt at specific temperatures, thus enabling the potter to determine when the firing is completed.
50. **Raku** - A soft, lead-glazed, hand-built groggy earthenware made in Japan and associated with the tea ceremony.

51. **Reduction Fire** - A firing using insufficient oxygen; carbon monoxide thus formed unites with oxygen from the body and glaze to form carbon dioxide, producing color changes in coloring oxides.

52. **Refractory** - The quality of resisting the effects of high temperatures; also materials, high in alumina and silica, that are used for making kiln insulation, muffles, and kiln furniture.

53. **Rib** - A tool of wood, bone, or metal, which is held in the hand while throwing to assist in shaping the pot or to compact the clay.

54. **Saggars** - Round boxlike containers of fire clay used in kiln lacking muffles. The glazed ware is placed in saggars to protect the glaze from the combustion gases.

55. **Salt Glaze** - A glaze developed by throwing salt (NaCl) into a hot kiln. The salt vaporized and combines with the silica in the body to form sodium silicate, a hard glassy glaze. A salt kiln is of a slightly different construction and is limited in use to the salt glaze.

56. **Sgraffito** - Decoration achieved by scratching through a colored slip to show the contrasting body color beneath.

57. **Sintering** - A firing process in which ceramic compounds fuse sufficiently to form a solid mass upon cooling, but are not vitrified. An example is low-fired earthenware.

58. **Slip** - A clay in liquid suspension.

59. **Stilt** - A ceramic tripod upon which glazed ware is placed in the kiln. Tripods with nickel-nichrome wire points are often used to minimize blemishes to the glaze. They are never used for high-fire porcelain which must be dry footed for greater support. Stilts may refer to the refractory posts used to support the kiln shelves.

60. **Stoneware** - A high-fired ware (above cone 1) with a slight or no absorbency. It is usually gray in color but may be tan or slightly reddish. Stoneware is similar in many respects to porcelain, the chief difference being the color which is the result of iron and other impurities in the clay.

61. **Stoneware Clays** - Clays more plastic than a porcelain body, firing to a gray color.
62. Terra Cotta - An earthenware body, generally red in color and containing grog. It is the common type body used for ceramic sculpture.

63. Throwing - Forming pottery of plastic clay on a potter's wheel.

64. Underglaze - Colored decoration applied on the bisque ware before the glaze is applied.

65. Vitreous - Pertaining to the hard, glassy, and nonabsorbent quality of a body or glaze.

66. Warping - Distortion of a pot in drying because of uneven wall thickness or a warm draft of air, or in firing when a kiln does not heat uniformly.

67. Water Smoking - The initial phase of the firing cycle up to a dull red head (1000° to 1100° F). Depending upon the thickness of the ware, this may take from 2 to 3 hours for thin pottery, to 12 hours for sculpture. The heat rise must be gradual to allow atmospheric and chemical water to escape. In some cases there will be organic impurities which will also burn out, releasing carbon monoxide.

68. Wax Resist - A method of decorating pottery by brushing on a design with a warm wax solution or a wax emulsion. This will prevent an applied stain or glaze from adhering to the decorated portions. The wax may be applied to either the raw or bisque ware, over or between two layers of glaze.

69. Wedging - Kneading and cutting plastic clay, forcibly throwing down one piece upon the other in order to obtain a uniform texture free from air pockets.¹

BIBLIOGRAPHY


REFERENCE SOURCE

INTRODUCTORY METAL ARTS
Metal jewelry has long been accepted for its aesthetic role; to beautify and adorn the body. Yet, the functional aspects have proven since Paleolithic times (20,000 - 10,000 B.C.) to be of significance to both creator and wearer. Such common pieces as pins, buttons and buckles served throughout history until today, as utilitarian forms.

A most common example of functional jewelry is the safety pin. A direct descendant of the Roman fibula (fastner), the hearty and handsome "safety pin" held togas and Scottish kilts in place.

Jeweled buttons appeared on most central Asian tribes, as well as the 18th century "dandies." The signet, a pin or pendant and later a ring, made a mark in wax or clay to identify as a personal symbol and seal for messages and products of quality. Finally, before banks and vaults, wealthy nomads and travelers carried ornate pieces of jewelry and gems, concealed on their bodies to protect their fortunes.

Jewelry is often associated with social status. The Aztec king was the only one permitted to wear a turquoise nose piece. Chinese mandarins often wore elaborate fingernail cases that rendered them incapable of even the slightest manual task, demonstrating that they were waited on literally hand and foot. European monarchs were often ladden with crowns and massive arrays of jewelry.

Today, fraternity pins, military insignia and lodge pins serve to identify members. The largest member organization is symbolized by the marriage ring.

Jewelry is often symbolic of religious or magical connotations. The cross and the star of David are commonly recognized symbols. In primitive societies the world was viewed with fear of the unknown. Jewelry was worn to ward off evil. Most often teeth, bones or feathers of animals adorned warriors to give them the animal qualities of cunning, fleetness and strength. Amulets, talismen and charms were protective pieces worn by knights and kings, illustrating the high quality of workmanship and precious gems. Zodiac birthstones were organized during these times of Medieval spiritual mystery. In England, Queen Elizabeth's grief for her lover, Prince Albert, brought into vogue, jewelry made of the deceased hair. Burial urns and jade outfits in China and Asia, Egyptian mummy masks and in the Dark Ages of Europe, small symbolic skulls were worn in recognition of the dead.
The most commonly associated value of all jewelry is its means of expression. The personality of the wearer and the imagination of the creator join in the piece to provide a psychological picture of the two.

METALS DESIGN

Designing for Metal Art work can be one of the most perplexing tasks for any beginning student. Each step requires forethought and planning based on a sequence that is dictated by the natural limitations of the materials. It becomes increasingly necessary to have a working knowledge of all aspects of quality design, for it is often a time consuming, frustrating experience to alter your work once a stage has been completed. This is not meant to stifle your creative thoughts, but rather to prepare you for the organization of your ideas. Certainly, all designs change in the progression of the processes, to grow and mature in an ultimately refined expression.

Design is analyzed scientifically into its simplest components or elements and then categorized by the interrelationships of the elements into principles. In metal art, all of the elements of design are intertwined because of the unique two- and three-dimensional qualities characteristic of the material.

Line is perhaps the simplest and yet the most significant element in jewelry design. Line can be drawn or integrated into the surface of metal. It can be represented by the edge or contour of a form or even indicated by the meeting of different colors or textures. The impact of line varies from static geometric precision to flowing curves to an organic "scribble."

The workings of form, shape and space are very closely associated. Form encompasses the three-dimensional description of design. Shape involves the two-dimensional qualities, with space as the "air" defined within and around a piece by both form and shape. As in line, these three elements can be categorized by their geometric or organic qualities. The geometric forms and shapes are based primarily on variations of the square, circle or triangle and impart, an uncluttered machine-like quality. The organic design is intrinsic to nature and an amorphic or free-form description.

Texture is the surface treatment incorporating all of the previous elements. It is a series or often a pattern of markings as low relief that provide a distinction from smooth polished surface characteristic of processed metals.

As an element of design for metals, color may appear at first to be rather ineffective as a visual stimulus. However, the subtle variations in the color of metals can be quite impressive. As well, the use of oxidation and stones or gems can lend high quality

---

1 Phillip Morton, Contemporary Jewelry (U.S.A., 1976), pp. 3-10.
2 Ibid., pp. 88-91.
variations in hue. Enameling acts most dominently to introduce a virtually limitless array of colors to metal. A jeweler may choose to use enamels much like a painter's palette.

In considering the principles of design, three are most commonly associated with metal work. Equilibrium or balance refers to the visual weight of elements within a design. There are two distinctions or types of balance relationships. The symmetrical or "mirror-image" is, if divided down the middle, exactly the same on one side of the axis as on the other. It is perhaps the easiest to accomplish, but must be handled in a sensitive manner to avoid a boring result. The asymmetrical form of equilibrium is the result of a visual imbalance. An inherently more dramatic visual impart is derived from the tension or strain of visual weight.

Focal point is sometimes referred to as the center of interest. A desirable aspect of design, it draws attention to the piece and causes the eye to revolve throughout the design. It serves the jeweler as an opportunity to achieve maximum contrast in color, texture, form or space.

Proportion and scale are the relationships of sizes, based on a natural sense of order. The reference to visual knowledge, or what has been seen and related to, is an important factor in the manipulations of these principles. For it is this knowledge that determines what fits "right" or "wrong."

After all is considered, the most influential aspect of design is personal taste, for it is the intimate expression of the creator and the attachment of the wearer that distinguishes good from bad. The elements and principles are basic guidelines with which to organize your creative thoughts.

---

3Ibid., p.91.
5Morton, p.95.
6Ibid., p.96.
The study of metal arts history presents an unusually difficult problem, very few remnants remain from early civilizations. The reasons behind this fact are that there was an absence of technical knowledge regarding metal and its processing, which means it was a scarce commodity. That which was available was relatively small and quite portable; therefore, thievery and pillage from wars and conquests make it difficult to trace its true origin. In substitution for the presences of precious metal and gem stones, softer materials such as bones, ivory and wood, etc. were used.

Mesopotamia, located between the Tigres and Euphraytes Rivers, was the site of Sumarian metal craftsmen. Over 4000 years ago, this ancient society refined wire and sheet metals into jewelry much like that which is worn by men and women today. They had perfected many of the surface treatments known to metalsmiths in the modern world, and they had a profound influence on development of Greek and Byzantium metal work.

The stability of the Egyptian civilization, which lasted for thousands of years, enabled metalsmiths and craftsmen to refine the techniques of forging, planishing, drawing wire and soldering. The discovery of Egyptian paste sparked the use of color in jewelry. Interestingly, these fabricated beads were of equal value with gemstones; for it was color not stone quality that was important. Even before 3000 B.C., the Egyptians were producing the finest quality metal ware for both humans and gods. Amongst the many symbols fabricated to please man and spirit was the now popular scarab, which stood for rebirth.

The Crete and Mycenae peoples' greatest contribution was artistic not technical. Their works symbolized the active, physical lifestyle in moving, graceful, light forms.

The Greeks had a simple beginning, making mostly twisted bronze wire forms. However, between 800 and 675 B.C. the appearance of gold, silver and electrum (an alloy of gold and silver) in the form of earrings, animal, human and mythological themes became popular. The artisans explored gold casting, filigree, chain making and granulation.

During the Hellenistic Period, the conquests of Alexander, the Great spread the Greek influence to the Orient. Conversely, the Orient influenced Greece, thus minimizing distinctions between cast
and west in the classical world. The greatest effect was the increase in production. As well, the use of lavish stones of brilliant color, dipped enamels and in general, a more complex and decorative style, symbolized the exchange.

The Romans' metal work grew slowly until 250 B.C. when the international Hellenistic movement brought Greek goldsmiths to Rome. Pieces such as bracelets, pins, fibulas, earrings and finger rings became most popular. "Niello," a technique where chiseled and engraved lines were filled with a black substance, a mixture of lead, silver and sulphur. The perfection of "opus interassile" in which sections of sheet gold were chiseled out, brought about embossed gold, one of the favorite techniques of Roman metal artisans. Much of the Roman jewelry is represented in Byzantium, which passed into Medieval Europe.

Another unusual collection of work comes from the Nomadic tribes of Russia and Mongolia. Among their extraordinary accomplishments were the setting of stones and cloisonné, done with a high degree of complexity. Most of their subject matter was distinctive and descriptive of their lifestyle with very active fighting men, animals and great hunts. Elaborate belts and buckles, horse trappings and chariot decor were the usual pieces produced. The incredible aspect of their work is that it was done "on the run," for they never established permanent communities.

The Chinese pieces are predominantly from the Ch'ing Dynasty (1644 - 1612) which unfortunately were Manchurian and rather uncivilized compared to other Chinese work. However, about 1000 B.C. ritual bronzes showing a mastery of metal casting and welding. During the Sung Dynasty, considered the Renaissance of China, produced some of the most beautiful work the world has known, characterized in their hair pieces and head ornaments.

In general, Chinese jewelry illustrates an emphasis on workmanship and ingenuity, not the precious quality of the material. It is characterized by delicacy, asymmetry, with tasteful irregularities in design. Their concern for movement and sound are illustrated by The Emperor's belt which had pieces of jade with complimenting resonance that let him walk to his own "music."

Unfortunately, little jewelry remains from before the 18th century in India. However, they were influenced little by other than their own past. The amazing variety of ornaments developed by the Indian craftsmen such as nose ornaments, anklets and toe rings, were characterized by unpolished metal enhancing brilliant stones.

The Greek city of Byzantium was to be renamed Constantinople when the Roman emperor moved his capitol eastward. The significance of this move is profound, for while the western culture declined into the Medieval Dark Ages, this eastern capitol flourished with
wealth and urban prosperity. This wealthy empire inherited the artistic traditions of early Greece and Rome. The Roman love of color in jewelry continued, but colored stones and a mastery of enameling techniques were added. Pendants on elaborate gold chains and exquisite earrings remained popular as in Rome.

The Celts and Vikings of western Europe were the first recorded civilization in that area. Much like the Nomads of Russia and Mongolia, their craftsmanship is extraordinary. As well, the pieces were rugged ornamental, protective ware, symbolizing their physical lifestyle.

After the Dark Ages and the Crusades, the development of craftsman guilds and production jewelry gave rise to skills and wealth of the Renaissance. During this enlightenment, Benvenuto Cellini became the forerunner of masters yet to come. The emphasis of work was based on elaborate crosses, reliquaries and pendants illustrating Biblical scenes.

The baroque period continued to represent man's rapid and profound changes in attitude. The subjects changed from the symbols of the spiritual to the fashions of floral designs and lace. Queen Elizabeth of England made popular a profuse array of jewelry. Spain became the wealthiest nation from the conquests of Mexico and South America. Cortez brought ship loads of gold and precious gems home to honor the monarchs of Spain. Essentially, the change in jewelry centered around monetary value rather than design and craftsmanship. In 1670 technical advancements brought about the development of gem cuts, and the quality of facets replaced the quality of color. The result was the dominance of diamond in fine jewelry, also the decline of design and metalwork, which is still present today.

The Royal Prussian Foundry began making exquisite iron pieces of jewelry. In England, the Victorian Age saw the technical advancement of production jewelry. In 1820, the development of "pinchbeck" (an alloy of copper and zinc) produced the first cheap gold pieces, followed soon (in 1850) by the discovery of electroplating. The ultimate effect was to develop a new market for jewelry, namely the rising middle class.

In the 20th century, European Art Nouveau was characterized by graceful, showy and exotic pieces. The emphasis on original design brought recognition to master artist-craftsmen such as René Lalique, Henri Vever, Georges Fouquet and Georg Jensen.

Yet another style took place in the early 1920's. Art Deco appealed to a Machine Age society, with a rejection of flowery, exotic nature themes or Art Nouveau. The influence of the German Art School, the Bauhaus, emphasized simple geometric machine-like quality work.

---

1 Morton, pp. 11-40.
The development of metal artistry in native America can be summed up briefly. The Inca's of Peru were the most significant factor effecting Mexican craftsmen and native American Indians. Their craftsmanship and technical achievements were unexcelled by any individual civilization in history.

Contemporary metal arts in America is best symbolized by listing the advancement of some pioneers in the art of metals:

(1) Sam Kramer - noted for his surrealistc approach messagery.
(2) Ronald Hayes Pearson - made the first individual crafts retail store prosper in the 1960's.
(3) Alexander Calder - a sculptor-jeweler is characterized by his untrammelled treatment of materials and an exploration into linear design.

The 1960's are basically described as having introduced metal work as an accepted, exhibited art form. However, in comparison to the early 1970's the work of the 60's was imitative of simple classical designs. The 70's on the other hand, have illustrated a mixture of crude and precious materials with varying textures and colors.

Symbolic of such combination and conflicts are the theoretical arguments between two distinct approaches to metal art. The followers of the Bauhaus feel the true value is based on a mastery of metal and tools, with an ultimate craftsmanship quality. The followers of Dada and Surrealism proclaim the fantasy and message of metal art is its most significant contribution.

The 1970's have, so far, developed a sincere interest in the exploration and refinement of historical techniques, with the advantages of modern scientific knowledge. As well, exploration into new processes and techniques such as electroforming, and materials like plastics are characteristic of the searching of the 1970's. However, possibly the most important aspect of present day metal arts work is the effort to achieve equality in recognition for its technical skill and its expressive quality.

³Morton, pp.11-40.
The distinction of metals that will be used in this beginning class is rather simple; ferrous or those containing iron and non-ferrous metals such as silver, copper and brass will be used primarily for jewelry objects. Steel is the ferrous metal we will use in a decoratively functional manner. Some materials and equipment are used specifically for each type of metal and will be described later in the processes and techniques section.

Metals preparation, one of the most common problems confronting the metalsmith, is working with the metal while it is soft enough to form. Steel must be worked while it is hot; for when it is cooled, it returns to its tempered or hardened stage making it much more difficult to move. To facilitate working with hot steel, a forge or open heat chamber is blasted with forced air to maintain a temperature adequate to keep the metal "cherry red" between work. Silver, copper and brass must be annealed or heated to an overall red heat, then quenched (cooled in water) and pickled (boiled in an acid and water solution) between working periods. The reason being, that as you work with the annealed piece, it becomes brittle from work hardening. Work hardening compacts the metal particles so closely together that they will not bend, but crack or break with use.

Torches - The most common method of heating employed for small pieces or areas of metals is the torch. They are available in a variety of types and sizes, however, they all produce two conical flames. The inside flame is a sharp, blue point, the very tip of which is the hottest. We will be using two different types:

(1) the Portable Propane Canister - has a variety of tips to accommodate many different heating jobs.

(2) the Oxygen-Acetylene Torch - by far the hottest of the two, it has two canisters, gauges and hoses that connect to the valved tip. On the oxy-acetylene torch, the gauges must be set depending on the task. (This will be done by the instructor.)

Hammers, Stakes and the Anvil - One of the most frequently used tools is the hammer. As with the torch, a wide variety is available, each having its function in the process of changing the form of metal. The purpose of hammering is to compact and stretch the metal in one or more directions. To accomplish this, a softer metal is sandwiched between harder metals; in our case, a hammer and
a stake or anvil. Some of the hammers we will use are:

(1) Rawhide Mallet - this will not stretch or dent the metal, the mallet is used to bend or flatten soft metal.

(2) Forging Hammer - a straight-edged head used with a stake to thin and spread the metal.

(3) Sledge - used on steel, this heavy weighted hammer is primarily to form.

(4) Planishing Hammer - with two highly polished, head face surfaces; one flat and one slightly convex, the planishing hammer is used with a stake on annealed non-ferrous metals only. It is used to finish and smooth the marks left by the forging hammer.

(5) The Anvil - is a heavy, multi-shaped, hard steel "block." It is used to form hot steel, with two holes to accommodate a variety of anvil heads and stakes; it is also used to bend and hot punch steel.

Files, Sandpaper and the Grinder-Polisher - Once the metal has been heated and hammered, finishing is the next appropriate step. Files are used first because they have the most "tooth" or cutting ability. Files come in various lengths, shapes, and grades, ranging from 00, which is the coarsest, to 6, which is the finest. Select the file necessary to suit the job, beginning with the roughest. The "cutting" action is accomplished when the file is pushed forward; therefore, apply pressure on the stroke away from you.

(1) The Flat File - is used on straight edges and outside curves.

(2) The Round or Rattail File - is used on inside curves.

(3) The Barrette File - which is thin at the edges, has a smooth or safe side that will not cut. This file is used in small spaces to help protect the surfaces you may not wish to mar.

(4) Sandpapers - vary in grit or size and number of sand particles. The most common used by metalsmiths are carborundum grades from 100 (coarsest) to 400 (finest). More or less coarse are available, however, once the grades have been run through, the polisher is frequently used.

(5) The Grinder-Polisher - is an electric motor with carborundum discs and tapered spindles available. The "stone" wheels are used on steel to form and smooth. The muslin wheels, which should be marked, are used with compounds or red and white rouge and tripoli to achieve a high, polished finish.

The Jeweler's Saw - its frame has some unique features:
it is adjustable

(2) it holds a very thin blade to eliminate unnecessary waste of expensive metals

(3) it can be used to cut almost any shape. It is strung with the blade teeth pointing toward the handle and when properly tightened the saw blade should make a high pitch "ping."

---

1 These materials and equipment will be identified and demonstrated by instructor, with the aid of slides.
### MELTING POINTS

(Fahrenheit)

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Solders</td>
<td>350-500</td>
</tr>
<tr>
<td>Annealing Temperature</td>
<td>1200</td>
</tr>
<tr>
<td>Easy Silver Solder</td>
<td>1325</td>
</tr>
<tr>
<td>Medium Silver Solder</td>
<td>1390</td>
</tr>
<tr>
<td>Hard Silver Solder</td>
<td>1425</td>
</tr>
<tr>
<td>1 F. Solder</td>
<td>1460</td>
</tr>
<tr>
<td>14 K. Yellow Gold</td>
<td>1580</td>
</tr>
<tr>
<td>10 K. Yellow Gold</td>
<td>1625</td>
</tr>
<tr>
<td>Sterling Silver</td>
<td>1640</td>
</tr>
<tr>
<td>Standard Brass</td>
<td>1750</td>
</tr>
<tr>
<td>Fine Silver</td>
<td>1761</td>
</tr>
<tr>
<td>1/4 K. White Gold</td>
<td>1767</td>
</tr>
<tr>
<td>10 K. White Gold</td>
<td>1900</td>
</tr>
<tr>
<td>Fine Gold</td>
<td>1950</td>
</tr>
<tr>
<td>Fine Copper</td>
<td>1981</td>
</tr>
<tr>
<td>Platinum</td>
<td>3224</td>
</tr>
</tbody>
</table>

### METAL ALLOYS

| Soft Solders              | lead, tin   |
| Silver Solders            | silver, copper, calcium, zinc |
| Sterling Silver           | silver .925, copper .75 |
| Yellow Gold               | gold, nickel, copper, zinc  |
| White Gold                | gold, silver, copper, zinc  |
| Green Gold                | more silver, less copper than yellow gold |
| Red Gold                  | more copper, less silver than yellow gold |
| Brass                     | copper, zinc |
| Bronze                    | copper, tin |
| Nickel Silver (German Silver) | 60% copper, 20% nickel, 20% zinc |
| Pewter                    | copper, tin, lead, antimony |

*Compiled by Richard Helzer.*
Annealing - as described briefly before, annealing is the heating of metals to realign the molecules and make the metal softer and pliable. Using the annealing tray, a shallow pan with pumice pebbles, light the torch and adjust it to a bushy reducing flame (slightly yellow at the tip). Run the flame over the entire piece until it becomes cherry red or about 1400°F. Quench the metal in water and then place it in the sparex or pickling solution. The acid and water liquid should be brought to a boil; this will eliminate firescale. Firescale is a thin black coating of waste which is otherwise difficult to remove. Once the pickle begins to boil, turn off the burner and retrieve the metal with the copper tongs so not to contaminate the acid solution. Rinse the metal and dry with paper toweling. The metal, having been annealed and cleaned, is ready for a variety of treatments.

Sawing - when the design has been traced or scribed into the metal, rest the metal on the v-shaped bench pin. Holding it steady with your hand, begin sawing with an upstroke, being certain as you continue, to draw the blade perpendicularly through the metal.

Piercing - is the sawing out of an inside shape. This is done by marking a center punch dent in the metal and drilling a small pilot hole. String the saw blade through the hold and proceed.

Soldering - this technique is used to join two or more pieces of metal by fusing an alloy of low melting temperature between the pieces. The process is used to connect and construct a variety of forms and shapes together, following a few basic steps:

(1) Make sure the metal and solder are cleaned thoroughly in pickle.

(2) The pieces of metal must fit perfectly together or there may be a gap in the seam.

(3) Set pieces together on a charcoal block.

(4) Drop very little flux (a solution to help the solder flow into the seam) into the joint.

(5) Light and adjust the torch flame to an efficient double blue cone.

(6) Play the flame gradually in a circular motion over the entire construction to provide an even heat. (Solder will flow to the hottest point.)
Gradually concentrate the circular wave of flame around the joint until the solder becomes molten and flows into the seam.

Quench and pickle the piece. If a tight, clean bond has been formed, very little other cleaning should be necessary.

When soldering more than one joint in a close proximity, it may be necessary to begin with hard solder on the first joint, medium and then easy on subsequent connections. "Yellow ochre" is a substance that can be painted on nearby seams to protect them when soldering. It must be used with caution because it will prevent the flow of solder if it contaminates an unsealed joint. When a complex design is desired, it may be necessary to wrap the pieces in place with thin steel binding wire.

Forging - the thinning and spreading of metal has been practiced for centuries. It is accomplished by annealing the metal first, then with a forging hammer and a smooth faced anvil, begin striking the metal. Note that the direction of the cross-peen end of the hammer must hit the metal firmly and soundly against the anvil, avoiding the hollow clap when all surfaces do not contact simultaneously. The metal will stretch and thin away from hammer marks. Be sure to leave the very edges thicker for strength and design. It will be necessary to anneal, pickle, rinse and dry several times to avoid cracks or breaks in the metal.

Engraving - on a variety of materials is one of the oldest art forms. It requires practice, but is essentially an easy surface treatment for metals. A bench pin brace, a block of wood to set the metal sheet on and a variety of gravers are all that are necessary. Hold the wood handle of the graver firmly against the heel of your hand. Rest your thumb against the wood block and exchange pressure from thumb to graver to engrave. Lines, gouges, dots or a pattern can be created with a few variations in gravers.

Etching - is the process of eating away metal in specified areas with nitric acid. The technique requires an extra clean surface, avoiding fingerprints, asphalt ground, a pointed scribe and a pyrex dish with nitric acid. Wash the metal with gasoline and then soapy water. Apply an even coat of asphalt over the entire piece of metal and let air dry. When it is dry to the touch, check to make sure all surfaces and edges are covered. Begin drawing your design through the asphalt with the scribe. Any mistake can be recovered with the ground. Carefully place the metal into the etching bath, face up to observe the acid "bite" depth. Brush away bubbles occasionally with a feather to permit even depth. After 5-10 minutes, the piece should be removed and rinsed with cold water. If the etch is deep enough, remove the asphalt with turpentine and finish the metal normally. A unique texture will be present in the etched areas; this could be enhanced by oxidizing the metal. Liver of sulphur will darken the metal when it is
boiled in it. Polishing the highlights will give an antique appearance and will accent the depth contrasts.

**Chasing and Repousse** - is pushing the metal into a low relief from the back. Chasing is much the same process from the front side. The chasing "liners" will give you much sharper details, however. A steel hemispherical bowl is filled with pitch and the surface is heated slightly to allow the metal to become embedded. Be careful not to sink the metal into the pitch by work before the substance is cool again. (Note that a pan of beeswax may substitute for the pitch bowl.) A series of chasing tools is used with a chasing hammer. Begin by pushing in the largest and deepest areas first. You will have to remove the metal occasionally as it becomes work hardened. Merely heat the metal until it can be removed easily. Anneal and clean the metal and repeat the embedding process.

Once you have achieved the desired design, turn the annealed and cleaned metal over on the anvil or tree stump. You may begin chasing to emphasize the surface delineations and develop details. The greatest distinction in these techniques is the angle that the tool is held. In repousse the tool is held perpendicular to the metal to punch the form. Chasing is done holding the tool slightly off perpendicular so that the tool follows a line over the surface of the metal.

**Enameling** - the most colorful method of treating the metal surface; enameling requires preparations and practice. The best metals for enameling are fine (pure) silver and copper. We will use copper for obvious economic reasons. Enamels adhere best to a slightly domed surface. The metal should be extremely clean and handled with copper tongs or tweezers. All soldering must be completed with hard solder. The enamels must be washed several times with clean water. Fill a mortar with the enamels and cover with water. Stir the enamels and pour off the milky water until rinse is clear.

There are two methods of applying enamels. The dry method is best for large surfaces. Involving the sifting of enamels through a sieve. Apply a reasonably thick and even coat. The second method is wet, with water added and painted on, usually for detailed areas. Preparation is now complete; the following steps will describe the rest of the process:

1. A counter enamel or scrap enamel is usually applied to the back first to help prevent cracking.

2. Apply a coat of gum solution to the back and sift the dry counter enamels on the surface.
(3) Caution! Be sure to coat all uncovered surfaces with scalex to protect against firescale.

(4) Place the piece on a nichrome wire mesh and put it into the preheated kiln.

(5) Watch through the peep hole until the enamels become glassy. This will indicate the melting maturity.

(6) Remove the piece and allow it to cool slowly on top of the kiln.

(7) Clean the face in pickle, rinse, dry and apply gum solution to the front.

(8) Dry coat with clear flux and fire.

(9) Next apply and fire opaque white if you do not want the metal color to show through transparent enamels.

(10) Now a variety of colors moisten with water are put in glass jars or mortars. The paste-like enamels are brushed on and fired until the desired result is achieved.  

---

1The processes and techniques will be demonstrated at appropriate times by instructor, with the aid of slides.
1. Abrasive - a material used to wear away a surface, to leave the surface smooth and even. Emery paper, crocus cloth and polishing compounds are common abrasives used by silversmiths.

2. Alloy - a mixture of two or more metals.

3. Ammonia - a solution used to dissolve and remove polishing compounds, rouge and tripoli.

4. Annealing - a process which restores a metal's malleability, ductility, and softness by heating (softening by heat).

5. Bench Pin - a device to support metal while sawing and filing. It is tapered with a "V" notch cut in one end and is made of wood.

6. Bezel - a strip of fine silver that encircles the base of a stone holding it in place.

7. Bobbing - a more traditional form for buffing and polishing.

8. Bright Dip - a process used to remove fire scale by etching the scale off in a series of dipping in a strong nitric acid solution alternated with scrubbing with pumice.

9. Brown and Sharp - a system of measuring the thickness of metals. An individual unit is called a gauge.

10. Brilliant Cut - a type of faceted stone cut. It consists of 54 facets. It produces the brightest reflection possible.

11. Burnisher - an oval-shaped, curved or straight, polished steel tool in a wooden handle. It is used for smoothing metal and setting bezels.

12. Burnout - the step in the lost-wax casting process where the wax is eliminated from the mold.

13. Cabochon - a type of stone cut so that the stone has a rounded top and usually a flat bottom.


15. Casting - to form an object by pouring or forcing molten metal into a mold.

16. Center Punch - a tool that makes a depression to start the drilling process.

17. Centrifugal Casting - a type casting where the molten metal is forced into a mold by centrifugal force.

18. Champleve - a type of enameling where the design is etched out of a metal plate and the etched out portions are then filled with enamel.
19. Charcoal Block - a block of specially prepared charcoal used as a support and to reflect heat back on the metal during the soldering process.

20. Chasing - to decorate a metal surface by indenting with a hammer and chisel. The metal is backed by a surface that is firm and resilient (pitch or lead). Chasing is done from the front side of an article.

21. Cloisonné - a type of enameling where each color is separated by metal wires.

22. Crucible - a container in which metal is melted.

23. Dapping - to make a dome out of flat metal.

24. Draw Plate - steel plates with tapered holes in graduated sizes used for reducing the size or shape of wire.

25. Draw Tongs - pliers especially made for gripping wire to draw it through a draw plate.

26. Ductile - the quality of metals which renders them capable of being drawn out or extended.

27. Electroplating - depositing very thin (less than 1/100,000 of an inch) layers of metal on another base metal.

28. Emery - an abrasive material that is composed of corundum.

29. Enamel - a vitreous glass in powdered form which is fused to the surface of metal by heat.

30. Engrave - to cut or carve design or lettering into the surface of metal by means of gravers (burins).

31. Etching - producing a texture or design on metal by means of acids eating on metal.

32. Facet - a flat surface cut on a stone.

33. Filigree - jewelry made up of delicate groups of wire.

34. Finding - a term that refers to ear wires, cuff link backs, pin backs, hooks, and other devices that will hold jewelry on to the wearer or to the wearer’s clothes.

35. Fine - any metal that is in its pure, unalloyed state.

36. Fire Scale (Fire Stain) - the thin coat of oxides that builds up during heating. It appears as a gray film on silver when contrasted to the true color. It will, if left on the metal, tarnish more quickly and be very dark and noticeable.
37. Flux - as used in silver soldering a borax mixture used to keep oxides from forming on the surface so the solder will adhere to the metal.

38. Flux Enameling - a colorless, clear enamel.

39. Forge - to form by hammering, to beat into a particular shape by reforming the shape or thickness of a piece of metal.

40. Fusing - a method of joining metal and producing a rough surface by melting the surface of the metal.

41. Gauge - the thickness of metal.

42. Girdle - the point where the diameter is the largest on a faceted stone.

43. Gold Filled - metals that are made by welding a layer of gold alloy to a base metal and then rolling or drawing the metal to the required thickness.

44. Hall Mark - an official stamp which determines the purity of the metal.

45. Investment - a material used as the molding compound for jewelry casting. Made of plaster, silica and other ingredients.

46. Iron binding wire - iron wire that is fully annealed used to hold parts together while soldering.

47. Karat - the term used to denote the relative measure of the purity of gold. (24 is fine gold; 14 is half gold; half some other metal)

48. Lapidary - a term used to denote the art of cutting and polishing stones.

49. Liver of Sulfur (potassium sulfide of sulfurated potash) - a chemical used to tarnish, darken or oxidize silver.

50. Lost Wax (cire-perdue) - the casting process that involves burning out of the wax mold.

51. Malleable - the quality of metal which allows it to be rolled out, compressed or moved within itself by hammering.

52. Mandrel - a tapered, calibrated steel bar with which rings are measured for size. Tapered steel bars of various sizes over which metal may be bent.

53. Matting - imparting a pebbled or drained texture to a surface of metal.
54. **Niello** - a metal alloy that is made up of silver, copper, lead sulfur, and sometimes antimony. It has a bluish-black color that when contrasted with silver or gold base gives a striking effect. Niello is fused in grooves or depressions.

55. **Oxidize** - in jewelry work, to darken the surface of silver, copper or gold with a solution of liver of sulfur.

56. **Pickle** - an acid solution usually composed of ten parts water to one part sulfuric acid, and used to remove certain types of firescale and to clean the metal after heating processes.

57. **Points** - a point is a unit of a karat (100 points equals one karat).

58. **Plique-A-jour (Window Enamel)** - a type of enameling where the enamel is fused into a metal frame and where there is nonmetal backing.

59. **Prong** - a metal peg that is bent over a stone to hold it in a setting.

60. **Pumice** - a fine stone powder used as an abrasive to clean the liver of sulfur from areas where it is not wanted.

61. **Quench** - to cool rapidly by plunging into water or pickle.

62. **Resist (ground)** - a material that covers the metal which is not etched away during that process.

63. **Repoussé** - to decorate a metal surface by indenting with a hammer and chisel. The metal is backed by resilient (pitch or lead). Repoussé is done from the back side of an article.

64. **Ring Clamp** - a holding device where the article to be held is placed in one end and the holding pressure is applied by placing a wedge in the other end.

65. **Rolling Mill** - a machine that is used to make sheet metal thinner.

66. **Rouge** - a polishing compound used to obtain the brightest polish on gold and silver. Rouge's polishing agent is red iron oxide suspended in a wax base.

67. **Solder** - solder is an alloy used to join two pieces of metal together by melting the two alloys into the joints.

68. **Spindle** - the tapered, threaded shaft on the buffing machines to which the buffing wheels are attached.

69. **Sprue** - a channel where the metal enters the mold and leads to the models.
70. Tripoli - a cutting compound used to remove scratches and pits from silver, copper and gold. The cutting material in Tripoli is pumice suspended in a wax base.

71. Troy - a system of weight measurements for precious metals:
   1 troy pound = 12 troy ounces
   1 troy ounce = 20 pennyweights (dtu)
   1 pennyweight = 24 troy grains

72. Trimming - a type of buffing done with a strip or strips of cloth. One end of the strip fastens to a stable object, the other held in the hand. The article to be buffed is rubbed up and down the strip.

73. Yellow Ochre - a substance that may be put on a solder joint to keep the solder from running out of the joint.*

*Compiled by Richard Helzer.
BIBLIOGRAPHY


