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CERAMICS: THE HISTORY, MATERIALS, AND

MANIPULATIVE TECHNIQUES OF THE CRAFT

(TITLE)

BY

James W. Mizener

PLAN B PAPER

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE MASTER OF SCIENCE IN EDUCATION
AND PREPARED IN COURSE

Industrial Arts 452, Recreational Crafts

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY,
CHARLESTON, ILLINOIS

1965

YEAR

I HEREBY RECOMMEND THIS PLAN B PAPER BE ACCEPTED AS
FULFILLING THIS PART OF THE DEGREE, M.S. IN ED.

July 14, 1965 [redacted]

DATE ADVISER

July 14, 1965 Walter A. Klehm

DATE DEPARTMENT HEAD

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INTRODUCTION

"Ceramics is a term used to describe materials which are very pliable in a raw or natural state, but which changes in structure when exposed to high temperatures, or "burned", becoming very hard and durable. They cannot be reproduced to again become pliable and adaptable to change."[1] There, fore, ceramics includes a wide range of products; pottery, plastics, glass, alabaster, cement, and others.

Ceramics dates back to nearly 5,000 years ago and is one of the most revered creations to man. It has survived over the years and continues to supply many challenging opportunities for learning and self expression.

Ceramics as a craft has much to recommend it. There is a great deal of enjoyment and pleasure that can be gained by successful experiences with ceramics. There are no special tools to master, and, consequently, no particular skills to develop before one can actually get to work. One can make pottery and ceramic sculpture without machines of any kind; many pieces can be made by hand. Yet, on the other hand, the use of tools and machines does not delimit creativity and self expression.[2]

Working with clay is a personal matter. Given a similar problem, no two people will produce identical results, for ceramic art is pure expression in its most basic form. Work with clay is one of many activities which offer opportunity to be creative in any degree - yet enables one to become acquainted with a material of significance in our present day civilization.[3]

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[1] Seeley, Vernon D. and Robert L. Thompson, _Activities in Ceramics_ (Bloomington, Illinois: McKnight & McKnight Pub. Co., 1956), p. 7.

[2] Zarchy, Harry, _Ceramics_ (New York: Alfred A. Knopf, Inc., 1954), Forward.

[3] Seeley and Thompson, _loc. cit._

Since the subject of ceramics is a vast one, this paper approaches ceramics almost exclusively with respect to pottery and ceramic sculpture. Selected factors pertaining to pottery and ceramic sculpture are considered. The history and development of the craft, contemporary applications, tools and equipment, working techniques, and decorating and firing are discussed. There has been a vast amount of material written on this subject but only those facts and information deemed to be important by the writer have been used.

This paper is the result of concentrated investigation of information available from the University of Illinois and Eastern Illinois University libraries.

CHAPTER I

HISTORY AND DEVELOPMENT

Ancient People

It would only seem reasonable that we should first investigate the history and development of our subject beginning with the people who contributed to the development of pottery and ceramics.

"The use of clay vessels is mentioned in the Bible; and recently, archaeologists have found relics of ancient kingdoms, some of which have been authentically dated as being at least 5,000 years old - some much older."[4]

Probably the first use of clay was to make brick, for various brick forms have been uncovered in Europe which are estimated as being 10,000 years old. The earliest recorded date in history is found on a brick tablet of the time of Sargon, who was king of Akkad in Mesopotamia, a very ancient kingdom. He lived and ruled the country at the eastern end of the Mediterranean Sea about 3,800 years before the birth of Christ. The dynasty he found lasted for two centuries and was the foundation for the Empire of Chaldea, which was noted for the development of astrology.

Many primitive tribes believed that when they died they would go on a long journey to another world, so food and drink was placed in the tombs or burial mounds in various kinds of containers. Many pottery relics are found

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[4]Seeley and Thompson, loc. cit.

in these graves. The clay utensils were not as perishable as those made of wood or metal, which crumbled into dust with the passage of time. Modern man has obtained many ideas of early history through the study of primitive man's early pottery.[5]

Glenn C. Nelson, author of a book entitled Ceramics, states that "no one culture or people invented pottery. Pottery making developed rather independently in various regions of the world when man learned to make fire and accidentally fired his first sun-dried clay pot."[6] The prevalence of a basketlike texture design on many prehistoric pieces suggests that clay was first used to coat reed baskets, fitting them for storage of wild-grain seeds. When one of these baskets was discarded and thrown on the fire, the greater hardness given the clay lining by the heat was noted. After this chance discovery had been observed, the first all-clay pots were made and fired. These early clay pots were impressed with a basketlike weave to resemble the reed basket.[7]

Glenn Nelson does state, however, that "the history of pottery and ceramics begins with the neolithic man. Pottery making doubtlessly began shortly after man was able to leave the nomadic life of the hunter, at least for a portion of the year, for the more settled life of the herdsman, fisherman, or seed-gatherer."[8]

Various ceramic pieces have been discovered that reveal early Chinese

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[5]Seeley and Thompson, op. cit., p. 65.

[6]Nelson, Glenn C., Ceramics (New York: Holt, Rinehart, and Winston, Inc., 1960), p. 152.

[7]Ibid.

[8]Ibid., p. 151.

ceramic sculpture dating roughly from 200 B.C. to 800 A.D. and covering the work of several important dynasties. Buddhism was introduced from India in about A.D. 500. An amazing amount of ceramic sculpture and pottery was made.

Mediterranean pre-Greek pottery ware from Etruscan and Cretan sources have been discovered dating back from 1600 to 500 B.C. A considerable amount of work was also done in Mesopotamia and in Egypt, as was stated earlier.

Pottery with a turned foot, indicating the use of a potter's wheel, has been found at a site in northern Iran and dated about 4,000 B.C. Use of the wheel spread rather slowly. By 1,000 B.C. a considerable amount of pottery was still not wheel made.

Crete developed a rather advanced culture long before Greece. While Cretan sculpture and architecture did not compare with Egyptian work, their ceramics were far more varied and interesting.

Little is known about the Etruscans; however, the most significant Etruscan work was in the field of ceramic sculpture. The ceramics and facades of their temples were covered with polychromed ware. An unusual but traditional ceramic piece was the burial coffin, often surmounted by a reclining figure.

The development of Greek ceramics follows the familiar pattern of the rise of a vigorous art form, the gradual solution of technical problems, and finally a decadence in which the pottery vessel served only as a surface for pictorial decoration. Their early works reflect a Minoan and, to a lesser extent, an Egyptian influence. The banded decoration of the early pieces with their delightfully stylized figures gradually gave way to one-panel designs featuring a single figure on a group of figures. The early Geometric ware (1,100 to 700 B.C.) generally had a tan earthenware body and brown slip-like decoration. The Greeks never used a true glassy glaze. Their so-called "black-varnish" glaze was really a dark iron-bearing clay slip with added alkaline fluxes. As the Greeks were interested in rather detailed figure drawings, they did not use glazes which might run. With pottery being such an accepted part of the culture, their various vase shapes became rather rigid types. The form of the vase became more mechanical. Since vases were used largely for decorative purposes, the Greeks added many non-functional features, such as flaring foot rims and sharp flat lips, which chipped and broke easily and are essentially more adapted to metal than clay. By 600 B.C. the prevailing style was the black-figure ware. Black-figured ware went out of style by about 520 B.C. when it was found that greater details could be achieved by using red figures against a black background. The Greeks continued to develop pictorial designs on what was now a rather codified set of ceramic forms. A variation was the use of a white background with a rather lineal drawing. By the fourth century B.C., the "florid style", with its complex backgrounds, overcrowding of the panel, and use of colors, had evolved. The scenes depicted became sentimental or comic. After the arrival of the Romans, the decline continued, and Greek style achieved a vulgarity of ornateness unparalled in ceramic history until the baroque and rococco period in Europe.[9]

During the Middle Ages, the decadent pottery skills of the Romans were lost to Italy. The revival of pottery making in Europe came from entirely unexpected sources. With the Moslem conquest of North Africa and much of Spain came the considerable skills of the Islamic potter. During the early Renaissance the prospering commercial centers of Italy imported pottery from Spain. This pottery, generally, but not always lusterware, is properly

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[9]<u>Ibid</u>., pp. 158-160.

called Hispano-Moresque ware, but because the trading vessels from Spain generally stopped en route to Majorca, all tin-enameled wares came to be called "majolica." The revival of Italian ceramics was rather short lived. With the success of the Renaissance painter, the potter also turned to painting, at first clumsily. Large plates were entirely covered with religious and mythological scenes. Their foot rims were made to serve as pictures, not as pottery. One interesting development during the Middle Ages in Spain and Italy was the work of the della Robbia family. Ceramic sculpture had been made for some time in Italy. Most of it was gilded and polychromed after firing. Although not the first to glaze such sculpture, Lucca della Robbia (1400?-1482) was perhaps the first to do it successfully. The lead-tin glaze he used gave the impression of white marble, although this may not have been his intention. Lucca founded a family business which continued for several generations, but unfortunately none of his successors had his ability as a sculptor. Not only were these later figures poorly modeled but gaudy glazes were used, which greatly distracted from the sculpture form. Lucca's work was not inferior to sculptors of his period who were working in other mediums.[10]

Little pottery of the eighteenth and nineteenth centuries in Europe has much esthetic merit.

Early attempts were made to establish the potter's art in America in the eastern United States up to the latter part of the nineteenth century. However, there was a notable change that developed. The earthenware products were designed for functional value rather than beauty. By the middle 1800's, companies were making pottery which was a modification of that made in Europe and England. As the American demand grew for fine durable tableware, American

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[10]Ibid., pp. 168-169.

potters wholeheartedly devoted their efforts to creating a product to meet the needs of an expanding new country until today we have some of the finest and most durable ware being manufactured.[11]

Chinese Contributions

Many of us have heard the term "China". China is a term used to describe the fine expensive clay ware of today. The term is used because the Chinese were the first to produce a clay utensil which was comparatively light and so fine that if a piece were held up to the light, the outline of fingers could be seen through it. If a china plate is rested on the tips of three fingers and struck sharply upon the edge with a pencil, the sound will be a clear bell-like tone. This kind of ware was produced in China as early as 87 B.C. The Chinese made their China from one of the purest of clays called Kaolin, which means "high hill". The ware was covered with a creamy mixture composed of water and various minerals, and fired at a great heat. The creamy mixture was melted or fused to the outside of the ware and made a glass-like covering. This was called glazing. Portuguese traders introduced the ware into Europe in the thirteenth century. In Italy the ware was called "porcelaine", a term derived from porcelana, the lustrous Venus sea shell which was compared with the smooth and shiny surface of the chinaware. Imitation of the beautiful fragile ware of China followed almost simultaneously in many countries.[12]

In making a further investigation into their history, we find that the Chinese have the longest unbroken ceramic tradition in the world and one of unusually high quality. Despite a succession of wars and changes of dynasties

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[11]Seeley and Thompson, <u>op. cit</u>., p. 65.

[12]<u>Ibid</u>.

the ceramic arts continued to develop and become one of the major art forms in China.

The T'ang Dynasty of China, which began in 618 A.D., lasted until 906 A.D. There is evidence that during this dynasty much youthful spirit was represented through earthenware, porcelain, white porcelain; also through tomb figurines. All of the wares that are accepted as belonging to the T'ang Dynasty, none is better known than that of the earthenware splashed with glazes that have flowed readily under the low-temperature heat that earthenware requires. Buff firing clays were used. The most familiar examples of this use are the numerous figures in the biscuit state which had been entombed in important T'ang burials. The glazes on this pottery can only be described as unique. They do not appear to have a Chinese ancestry that could claim relationship with them. They could have been invented by some genius of this dynamic people. They could also have come from the West, along the trade routes so much traversed at this time, but changing to become purely T'ang. The basis of their glaze composition was oxide of lead mixed with burnt sienna for the amber brown color. The green came from copper oxide and a deep brown from an umberous clay. These glazes also appear on the costumes of the clay attendants, and on the horses and camels that were entombed at T'ang burials.[13]

Sung pottery, 960-1279 A.D., is remarkable for its simplicity of forms and for the subtlety of its colors and textures. Other periods were to develop exact technical controls and more intricate processes, which were often applied with painstaking skill, but authorities are generally agreed that the quiet mastery of plastic expression reached by the Sung potters represents one of the highest achievements of the potter's art. It was during

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[13]Dalton, W. B., Craftsmanship and Design in Pottery (New York: Pitman Publishing Corporation, 1957), pp. 23-26.

this period that kaolin was introduced into clay, and the transition from porcellaneous stoneware to true porcelain was begun. The most justly celebrated Sung wares are the so-called transmutation glazes, celadons, copper reds, and flambe effects obtained by subtle manipulation of firing conditions, and the small tea bowls of dark stoneware clay glazed with a delicately configurated brown glaze.

In the Ming period, 1368-1644, the Chinese achieved technical mastery of porcelain manufacture. New and brighter colors were developed which could be fixed to the previously fired porcelia by means of a third fire at low temperature. Skill and mastery of execution gave way to the intricate "tour de force" as Chinese potters strove to satisfy the export demands of baroque Europe.[14]

Chinese pottery has survived the years and still appeals greatly to our sense of appreciation. Even today many of the technical achievements of Chinese potters are used in industry.

Contemporary Application

Industry

Man has needed and still needs ceramics, vessels to eat and drink from, to store liquids and solids in, for experiments in the technical fields, to wash and bathe in. He needs insulators, brick and tiles; and these are and will in our progressive time be made by industry.

Therapy

The application of ceramics to our current physical and manual arts therapy programs in our hospitals has been increasingly valuable as a means

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[14]"Pottery," Encyclopedia Americana, 1956 ed., Vol. XXII.

to an end; that end being the rehabilitation or re-establishment of the patients. Hospitals such as the Veterans' Administration Hospital of Danville, Illinois, introduce the craft as a part of the total integrated program. Childrens' Hospitals, Child Study Clinics, and Psychological Clinics are but a few institutions that introduce ceramics into their programs.

Schools

The pottery and sculpture phase of ceramics has much to contribute to education in art expression for all students at all levels in our present day school curriculums.

In many cases this craft is integrated into the elementary curriculum to vitalize instruction. At the secondary school levels the craft is many times introduced as a part of a total program of industrial arts or art in courses such as "applied arts," "recreational crafts," etc. At the vocational and technical level, schools such as O'Fallon Technical High School in St. Louis, Missouri, support technical ceramic programs. The end products of such programs are often sold commercially to help finance the program.

Recreation

Ceramics as a part of a person's recreation or hobby can be very rewarding. Ceramics is one of this nation's favorite pastimes and offers both excitement and practical uses to those who choose to endeavor in the craft.

"Since the end of World War II, ceramics has mushroomed in popularity until today it is one of the nation's pastimes. Its enthusiastic adherents are outnumbered only by those of bowling, fishing, and stamp collecting."[15]

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[15]Engel, Gertrude, How to Make Ceramics (New York: Arco Publishing Co., Inc., 1957), p. 15.

As for creative recreation, there are more ceramists in the country than any other breed of amateur artist.

Where formerly a potter had to possess the technical skills of a chemist and an engineer to work out formulas for clay bodies and glazes, it is now possible to buy prepared clays and glazes with easy-to-follow directions. As a result, in the past dozen or so years, American-made ceramics have equalled, if not surpassed, those of famous and respected Old World potteries.

The application of modern science has removed every trace of drudgery from the ceramic art. It has been distilled into pure fun. Youngsters are being taught ceramics in thousands of schools, as already mentioned; youth organizations such as 4-H clubs, Boy Scouts, and Girl Scouts; summer camps such as church camps, conservation camps, recreation camps, and many others.

The vast majority of professional clay workers today got their start as amateur hobbyists. After they advanced far enough, they found that people were willing to pay for the ceramic goods they produced. However, the primary objective of most beginners is to have fun and at the same time create fine ceramic items to enrich their home.[16]

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[16] Ibid., pp. 16-19.

CHAPTER II

CERAMIC CONSTRUCTION

In this chapter we will seek to present information concerning the raw matter from which clay pieces are constructed along with information concerning the classification of clay, basic tools and equipment, and methods and techniques of ceramics.

Clay

The most important single material used in pottery and ceramic sculpture is clay. Clay is found all over the earth. Because of its wide distribution, it has been used by every civilization since long before the dawn of history.

Chemically, clay is a hydrous aluminum silicate, formed by the disintegration of certain kinds of rock. Clay may be roughly divided into two types: (1) residual, and (2) sedimentary. Residual clay is found together with the rock from which it was formed. This clay is subjected to the action of wind, rain, frost, and upheavals of the earth's crust, so that its mass is constantly being broken up. Originally found on high mountainous ground, it may be washed down into streams and carried for great distances. Eventually it is deposited in rivers, lakes, and pools, where it becomes known as sedimentary clay.

Residual clay is purer than sedimentary, a perfectly pure state, as it is mixed with vegetable matter, sand, silt, rocks, and mineral oxides. The mineral content of clay gives it its color; it may be yellow, green, gray, red, black, or almost any other colors one can name. Sedimentary clay is usually more plastic or workable than residual clay because it contains more sand and has been subjected to a long period of grinding while being carried to its final resting place.

There are many different kinds of clay, but there are only a few which can be used by the potter as they occur in their natural state. Clay for ceramic use must have three desirable qualities: it should be plastic, porous, and capable of being vitrified, or hardened by heat.

A plastic substance is one that may be pressed or molded into any desired shape. In this respect, clay is unique. No other material fashioned by nature is as pliable or plastic as clay. When wet, clay forms a mass that can be pushed or pressed into an infinite variety of shapes. When it dries it will retain the exact shape into which it was formed. Some clays are short, possessing little plasticity; this is particularly true of some residual clays. Before they may be used, they must be mixed with clays that are very plastic, or long.

According to Harry Zarchy, clay should be porous. Some clays have dense bodies, in which the particles that make up the mass are very closely packed. Clay of this type may be mixed with sand, which gives the body a more open texture. This permits it to dry without cracking or warping, as the moisture can escape more easily and evenly. This is particularly important when the clay is fired.

Vitrification is the process by which the clay is fired, making it hard, dense, and stonelike. Some clays are refractory, or incapable of being melted in a kiln. Others may have a low fusing or melting point, so that they cannot be fired satisfactorily. A good ceramic clay is one that can be fired hard without warping, cracking, or sogging. Since very few natural clays meet these requirements, most clays used in ceramic work are blends of several different clay bodies.[17]

For school purposes, whenever possible, it is simpler to buy clay in a moist state, but it can be purchased in a dry powder form and mixed as needed. This will require several days depending on the atmosphere and temperature of the room in which the clay is mixed.[18]

To prepare clay from the dry powder: The powder should be spread in a sink, tub, or flat pan and mixed with water to the consistency of thick molasses. All lumps should be removed by stirring until it is smooth. So long as clay is moist, it is very plastic and easy to work. If it is pushed, it moves readily and stays in the new shape. If a piece of clay is added to the original piece, it is only necessary to lay it firmly in place and work it into the mass with a finger or tool. But once the clay has hardened, it is practically impossible to add moist clay to it.[19]

With regard to storage, plastic clay should be kept in a sealed container. The advent of plastic sheeting has contributed greatly to the field of ceramics. Moist clay may be wrapped in plastic sheeting and kept in storage for an infinite length of time and still remain in a moist state. Sculpture pieces may be kept in a leather-hard condition from day to day by merely draping plastic sheeting over the sculpture at the end of each working period. For hand-shaped pottery, the clay must be kept soft, not sticky, and firm, not shapeless. For sculpture, it should be stiffer so that it will not slump or sink or lose its shape.

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[17]Zarchy, op. cit., pp. 3-5.

[18]Duncan, Julia Hamlin, How to Make Pottery and Ceramic Sculpture (New York: Doubleday & Co., Inc., 1960), p. 12.

[19]Engel, op. cit., p. 28.

When clay is very stiff it may be reclaimed by leaving it on a moist plaster bat, covered with a damp cloth. Clay that is bone-dry must be broken and mashed and worked like dry powder clay. It is far better to err on the side of keeping clay too wet than too dry.[20]

Classification of Clay

There are three classifications of clay according to density and firing temperatures: earthenware, stoneware, and porcelain.

Earthenware

Natural clay bodies classified as earthenware clay, are red or brown when fired. Some characteristics of this clay are rather course grain, porous, low chipping resistance of completed items, and tendency of projects to deform if heated to excessive temperatures. Because this type of clay is fired at a comparatively low temperature and is generally an inferior grade, pottery made of this clay absorbs liquids and moisture. However, when glaze, or a glass-like coating, is applied and then fired, it becomes semi-vitrified and capable of holding liquids. Earthenware pottery matures at temperatures of 1800 to 2100 degrees, Fahrenheit. Because its color is usually buff or red, it is often covered with a white slip or "engobe" before glazes are applied. Leaving it partially textured, however, often effects a pleasing contrast to the smooth glazed areas.

Stoneware

Stoneware might be described as porcelain of rather inferior quality. It may be made from natural clay or from a prepared body containing a high percentage of alumina and silica. It is fired at a higher temperature than

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[20] *Ibid.*, pp. 28-29.

earthenware, usually about 2300 degrees, Fahrenheit, and as a result is hard and vitreous, and quite impervious to water. Not all clays (natural) can be used for stoneware, for many of them, especially the red ones, would melt and deform at stoneware temperatures. The fired stoneware body usually has a gray color which is due to the presence of small iron impurities. This body color is the only difference between it and the low-fire porcelains.

Porcelain

Porcelain is fired at the highest temperature of all clay products. It is always made from a specially prepared body of kaolin, ball clay, feld-spar, and flint. Since this mixture is not very plastic, it requires more skill to work and aging is almost a necessity. The temperature ranges of porcelain are from 2300 to 2670 degrees, Fahrenheit. There is a slight difference of opinion between Oriental and Western definitions of porcelain. By European standards, it must be white, completely vitrified, and translucent in the thin areas. The Chinese agree that porcelain should ring sharply when struck, but they feel that translucency is not necessary and they will accept bodies with a slight gray color. The gray color is due, in part possibly, to the rise of a gray body or iron oxide to color a white body when a celadon glaze was applied. By so doing, they obtained a better quality color.[21]

Tools and Equipment

In ceramics, as in any other craft or hobby, certain equipment and tools are necessary. However, it is not necessary to have complete and elaborate equipment to be successful. A kiln represents the major item and expense. Beyond the kiln, the basic tools needed are as follows:

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[21]Nelson, op. cit., pp. 10-12.

#1. Wedging Wire. This tool can be made by attaching two pieces of ½" dowel to the ends of a 2" copper wire, about 18 gauge. It is used to cut blocks of clay in two in the wedging process. The dowels are used as handles, but they also make the wire easy to find.

#2. Knife. A knife is needed for all trimming and cutting processes, but especially for trimming tiles. Any knife with a short blade, such as a paring or sloyd knife, will do.

#3. Metal Pallets. Pallets are used for smoothing or scraping the surface of clay. These come in a variety of shapes and sizes with a plain cutting edge or a toothed edge. The toothed edge scrapes the high places or bumps quickly and easily, but the surface is finally smoothed with a plain cutting edge. Often the plain cutting-edged pallet alone is enough to smooth the surface. Two or three metal pallets will cover most needs.

#4. Rubber Pallet. A rubber pallet is used to clean glaze or slip from the mortars or pans in which they have been mixed. The pallet not only cleans the container, but saves the slip or glaze.

#5. Pointed Tool. A pointed tool is needed for a variety of processes, such as incising designs on pottery, or doing sgraffito decoration (scratching designs through slips into the surface of pottery). A 3/8" dowel about 6" long, with a nail inserted in one end, makes an excellent tool.

#6. Elephant Ear Sponge. This is a flat, thin, fine-grained, natural sponge, similar in shape to an elephant's ear, from which it gets its name. It is used for finishing surfaces and edges of pottery and sculpture. Cellulose complexion sponges can also be used.

#7. Brushes. Several soft, hair brushes are needed for applying slip and glaze, and for mending. These can be of average quality, such as imitation camel's hair. Numbers 3, 5, 8, and 10 will serve all purposes.

#8. Syringe. A syringe is used for slip decoration. A hand irrigating syringe with hard rubber nozzle and a bulb can be purchased in any drug store.

#9. Wood and Plastic Modeling Sticks. Choose a number of modeling sticks of a variety of shapes for the modeling, working, and finishing of clay. Sticks about 6" to 8" long with thin, flat blades are preferable to thick, large ones. The blade ends are used for cutting, smoothing, and shaping surfaces and for welding fine lines. The round ends are used for welding coils together and for general modeling and shaping.

#10. Wire Loop Tools. Several loop tools with tempered metal loops are necessary for smoothing the surfaces of pottery and sculpture, especially for cutting down high places, for hollowing out sculpture before firing, and for carving and sgraffito work in the decorative processes. It is advisable to select three or more tools of sizes varying from 8" to 10" long, and with various shaped loops.

#11. Tiles or Plaster Bats. Tiles or plaster bats are needed for supporting or for keeping objects moist while working on them. Unglazed biscuit tiles, 4" x 4" and 6" x 6", are adequate for most projects. They may be purchased from a ceramic supply house. Plaster bats can be made. They can be used for any size, and especially for work requiring a base larger than 6" x 6".

#12. Wedging Table. If any considerable amount of clay work is to be done, as for example in class or group work, a wedging table is essential. This is a table about 2' deep and 3' long with a cement or plaster top. (The top can be made by first constructing a box about 6" deep with a solid wood bottom. Half fill the box with gravel or pebbles and pour cement or plaster into it until it is even with the top.) A wedging wire is arranged by erecting a 1" x 2" post at the back of the table. This should project about 2' above the table top and extend down as far as necessary to be well supported. It should be anchored to the table with screws and bolts. A steel piano wire is stretched from the table. A 2" turnbuckle, set near the top, will help to make the wire taut. (In using the wedging table, the clay is cut in two by pushing it against the wire and slamming the two pieces on top of each other.)[22]

Methods and Techniques of Ceramic Construction

Wedging Clay

Each time clay is used - before beginning any of the projects, or when resuming work if a piece is put away before completion - the clay must be wedged. The purpose of wedging is to remove all air pockets and holes which would cause a piece to explode in the firing; to eliminate foreign matter such as nails, cloth, and leaves; and to secure an even consistency.[23]

A lump of clay is held in both hands and cut through the wire of a wedging board. One half is thrown down onto the wedging surface with one hand. The second half is brought down with the other hand; the cut edges facing in opposite directions. Beginners are often awkward in bringing down the piece in the left hand and want to transfer it to the right hand as soon as it is empty. They should be encouraged to use both hands and, since the aim is usually better with the right hand, to throw the left-hand piece down first, then the right piece on top of it. The steps are repeated, until all entrapped air and striations have been removed.

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[22] Duncan, op. cit., pp. 8-9.

[23] Ibid., p. 12.

Wedging may require only a few repetitions of the steps or it may require many, depending upon the conditions of the clay and the amount of water in it. The longer the wedging continues, the drier the clay will become, so it can be too prolonged - a favorite pastime of beginners - clay which is too soft to wedge, may be dried on a plaster bat first. Clay which is too hard can be softened as follows: the clay is cut into many thin slabs with the wedging board wire. Each slab is sprinkled with water or smeared with slip. Stacked like a giant sandwich and pressed together, the clay can then be cut into slices in the opposite direction and dampened again. A few repetitions of this sandwiching will soon bring the clay to a wedgeable consistency.[24]

Too much emphasis cannot be placed on the importance of wedging clay. This repeated mixing of the clay makes it very smooth and easily worked and produces better results in all phases of pottery work.

Hand-Built Modeling

Hand-built modeling of clay encompasses all methods of modeling excluding throwing on the potter's wheel.

There are various ways to make hand-built pottery: free form modeling; slab building; coil building; pounding; scooping; slinging; and draping. Three are discussed here.

Free form modeling can be a fun provoking enterprise for any beginning ceramist. It provides an opportunity for one to express himself and at the same time helps to develop a personal style of artistic craftsmanship.

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[24]Barford, George, Clay in The Classroom (Massachusetts: Davis Publications, Inc., 1963), p. 19.

Before attempting too ambitious a project, one should learn the fundamentals of forming an object with clay. Gertrude Engel recommends the following procedure for free form modeling. "Begin by taking a mass of wedged clay and shaping it into a ball or a void. Then, with both hands, squeeze and press it into a simple form. Use no tools other than your hands. Slowly organize the clay ball into an abstract shape which is esthetically pleasing. As you shape the abstract sculpture, organize the clay into rhythmic shapes and stress those lines which seem the most pleasing. After a person has gotten the feel of the clay, he can begin making simple pottery."[25]

When a person is engaging in free form modeling it is not necessary to worry if finger or hand marks show, for they lend interest and texture to the work. The hands should slide smoothly over the clay as it is worked; if they don't, dipping them in a bowl of water from time to time will help. This will lubricate them and help to achieve a smooth, sweeping movement.[26]

After the clay has been shaped to a persons satisfaction, it is best to stop work. The clay cannot be removed from the working surface immediately, because it is too soft; it will sag out of shape if it is moved. It should be allowed to dry until it is leather-hard. In this state, clay is no longer plastic, but it is still moist. Leather-hard clay may be carved, cut or scratched, but it cannot be modeled further.

Clay may be removed from a working surface, generally (plastic bat), oil cloth, canvas or burlap, by slipping a knife blade under it. The clay

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[25]Engel, <u>op. cit.</u>, p. 49.

[26]Barford, <u>op. cit.</u>, p. 24.

work should dry evenly in a location free from draft or heat; otherwise they will either warp or crack. When thoroughly dry, the article is ready for firing.[27]

Slab building is another form of hand-built modeling. Clay slabs may be used to make a variety of forms, from the simple tile to the complex sculptural pieces of many of today's potters. Whatever their destiny, the principle of forming the slabs is identical: the clay must be flattened.

The simplest way to flatten clay evenly is to place it on the reverse side of oil cloth or canvas and roll it flat with a rolling pin. Partial flattening, with the fist, the palm, and the pin, will hasten the final rolling. For this, two guide strips of wood, 3/8" x 1/2" thick and about 18" long, can be placed on each side of the clay, so the pin will ride on them.

A simple clay tile project will help the beginning ceramists understand the nature of slab work in general; however, projects made either of single slabs or forms built from a number of cut pieces may be undertaken to enhance one's experiences.

> A simple slab method piece can be made by cutting out clay in a shape similar to that of a red cross symbol. The four ends of the cross are bent up and the corners joined with thick slip, made of the same clay as the form. Joining slip may also be made with vinegar and clay; it has the advantage of requiring less liquid to achieve a paste-like consistency. All surfaces or edges to be joined should be scored before the slip is applied, assuring a better hand. If the edges to be joined are re-cut to 45-degree angles before attaching, they will fit more snugly. The soft clay form may require some support until it has stiffened.[28]

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[27]Zarchy, op. cit., p. 21.

[28]Barford, op. cit., p. 30.

> Round or free-form slab pieces may be made by first cutting the desired shape for the base from a rolled-out slab. A narrow strip, long enough to form the complete wall, is cut next. If judging the length required is difficult, a string can be placed along the top edge of the base; when straightened, it will provide an accurate measurement. The long strip is scored on one edge for its entire length and the base is also scored near the outside top edge. Thick slip is then applied and the pieces joined. The ends of the strip are cut at 45 degree angles, to provide a joint stronger than simple butting would afford. The form could be made taller by adding more narrow strips, much in the same manner as in coil building.[29]

"Coil-building is an ancient method of clay modeling; it is also one of the simplest. The American Indians and other primitive people built pottery in this manner."[30]

The base of a coil-built form may be made from a coil, with the resultant spiraling joint worked over firmly on both front and back. The base may also be cut from a flattened piece of clay or a clay disc may be domed slightly by pressing it over a form until it has stiffened somewhat, providing a cupped base.

When coil-building, the clay should be quite moist, on the verge of stickiness, since the coils must be pressed together firmly as the form is built. The clay should be rolled out with the hands into a rope-like shape.

> If the clay is sufficiently moist, the ropes need not be perfectly round because a certain amount of pinching, to thin the walls, is part of the process of coil-building. If the clay is too soft, on the other hand, the work will have to be interrupted by waiting periods while the form stiffens enough to proceed. Soft clay on soft clay will invariably slump.[31]

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[29] Ibid., p. 31.

[30] Zarchy, op. cit., p. 30.

[31] Barford, op. cit., p. 26.

The coils may be used in one of two ways: each coil may be placed flat and joined to itself when it has gone once around or it may be used in a spiraling fashion, proceeding as far as it will reach, there to be joined by the next. The former method is easier for beginners because the form can be kept under closer control.

The form can be given an outward curve by placing the coil on the outside edge of the proceding coil. An inward curve can be used to help keep the form symmetrical during the building process, although a greater sensitivity to form through visual and tactile senses will develop without this aid.

Some potters prefer to leave the pattern and texture of the coils and fingers as an honest expression of the way in which the form was made, allowing the play of glaze over them to provide "decoration." Sometimes, however, smoother surfaces may be desired for certain decorative techniques. In such cases, outside walls may be smoothed with a rigidly held knife, a hacksaw blade or any convenient scraper.[32]

Casting Pottery From Molds

Casting pottery from molds is a process in which slip (liquid clay) is poured into a hollow plaster mold. The dry plaster absorbs water from the slip, causing a clay deposit to be built up against the inside of the mold. When this deposit reaches the proper thickness, the slip is poured out of the mold, and the clay that remains inside is permitted to dry until it is leather-hard. The leather-hard piece is removed from the mold, fettled or trimmed, and set to dry.[33]

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[32] Ibid.

[33] Zarchy, op. cit., p. 38.

Single and Multi-Piece Molds Pottery shapes which flare outward from the feet to the rims, with no reverse curves in their profiles, may be reproduced in one-piece, drain-cast molds. Such molds are the least complex, the easiest to make and to use.

Pottery shapes which have curved sides must be cast in two-piece or multi-piece molds. These molds are a bit more complex to make and to use than the single piece molds.

The original shape, called the "model", may be made of virtually any material. Plaster, wood, metal, and clay are preferred, in that order, professionally. However, solid clay models are most commonly used in classroom situations. The method of forming the clay model depends upon the equipment available and the form desired. With regard to models used for making single piece molds, there is no limit to the types of shapes - round, square or free-form - as long as there are no reverse curves in the profiles or side views of the piece. The model is made upside down, so that when it is completed, plaster may be poured directly over it.

When making a single piece mold, a retaining collar or wall, called a "cottle", is used to confine the plaster when it is poured over the model. The cottle may be such that it will form a round mold in which case a strip of linoleum, roofing paper or even oiled cardboard may be used. If a square or rectangular mold is being made, pieces of oiled wood may be used. The angle formed between the outside of the cottle and working surface should be sealed with clay. This not only prevents leaks but helps to insure against any pushing outward of the cottle by the pressure built up as the plaster is poured in. If the model has been made of clay, no plaster separator is required. If it has been made of plaster, however, soaping is necessary.

When the model, cottle, and clay seal have been prepared, the amount of plaster needed to fill the cottle to one or two inches above the model is computed. The plaster is poured carefully into the cottle. As the plaster sets, it will give off a considerable amount of heat, due to chemical reaction. When the setting plaster is warm to the hand, the sealing clay and cottle may be removed. The model may be removed immediately. However, if the model is of clay and is remained in the mold overnight, or until it has undergone some shrinkage, it may usually be removed more easily. Any excess clay remaining inside the mold should be removed with a damp sponge and the mold set aside to dry before it is used for slip casting.[34]

Basically the same process for making a single piece mold is used for making multi-piece molds except that mold is made in parts. Wherever the model has a reverse curve, the mold is cast separately. This is so that when a casting is performed, the cast can be removed from the mold. An example of making a two piece mold is as follows:

> The first step in making a two-piece mold is to draw a horizontal line on the model where the mold is to be divided into two parts. The line should be drawn at the point where the curves reverse. Next, turn the model upside down and embed the lower half in soft clay. Bring the clay right up to the line you have marked on the model. Use four pieces of wood to set up a form for casting. The top of the form should be about 2" higher than the model. The sides of each wood piece must fit snugly against the clay bed, with no openings visible. Seal the outside of the form with soft clay, and reinforce it by tying a cord around it. Size the inside of the form, the clay bed, and the model. Mix plaster and fill the mold. As soon as the plaster sets and begins to feel warm, remove the form. Remove the clay from the half of the model, leaving the remaining part imbedded in the plaster. Set the plaster down so the exposed part of the model is up. The next step is

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[34]Barford, op. cit., pp. 58-59.

> to cut notches or joggles in the plaster. When the upper half of the mold is cast, plaster will flow into these notches, forming raised triangles. When the mold is assembled for casting, the triangles in the upper half will fit into the notches in the lower half; the two halves of the mold will fit together perfectly.
>
> Once again, assemble the casting form, this time fitting the wood pieces against the plaster that has been cast. Size the inside of the form, the plaster, and the model. Mix and pour the plaster, filling the form. Allow the plaster to set, then remove the form. Separate the two halves of the mold carefully and remove the model.[35]

Preparing the Slip

> Liquid clay is called "slip" but there are several types, useful in different ways. Slip intended for use in molds is referred to as "casting slip" and, professionally, the term means something more than a mixture of clay and water. It is possible, however, to use such a mixture, and it may be considered as one of four ways of obtaining slip for casting. The other three ways are: (1) purchasing casting slip in the liquid state; (2) purchasing a prepared casting slip clay in the dry form; and, (3) preparing a slip specifically for casting.[36]

Specially prepared slip differs from ordinary slip clay and water in that it contains one or more chemicals known as deflocculants. The deflocculants, usually sodium silicate and sodium carbonate, increase the fluidity of the slip without making it necessary to add more water. The less water the slip contains, the less will have to be absorbed by the plaster mold. The chemicals also keep the clay particles in suspension, so that they do not settle out in the container or the mold; this gives a clay cast of even thickness throughout.[37]

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[35]Zarchy, op. cit., pp. 46-49.

[36]Barford, op. cit., p. 60.

[37]Zarchy, op. cit., p. 39.

Casting slips should be kept in covered containers, otherwise they tend to thicken and may develop thick crusts on top. They often need some agitation before use, preferably stirring by hand from the bottom up - so air will not be worked in - and screening.[38]

Casting Casting with slip is a relatively simple process but it is strictly manipulative. The mold is set on a level surface, or made level. The slip is poured into the mold from a pitcher for ease of handling and control of pouring speed. It should be poured evenly, with the initial stream directed to the bottom center of the mold. Slow pouring is not necessary; that the pouring be steady and even, without splashing - which could entrap air in the slip - is more important. When the slip has reached the top of the mold, pouring is continued until a slight mound forms above the mold. Surface tension causes and permits a slight bulge above the level of the mold top.[39]

The plaster mold will absorb water from the slip. How quickly, will depend upon a number of factors, including: (1) the dryness of the mold; (2) the percentage of water in the slip; (3) the character of the clay being used; and, (4) atmospheric conditions. As the water is absorbed, the level of the slip will lower. When this occurs, a little more slip may be added, until the level is again slightly above the top of the mold. While the slip remains in the mold, the plaster continues to draw water from it and wherever it is in contrast with the plaster, a wall of moist clay is formed. The longer the slip remains in the mold, the thicker the wall becomes. When the wall is of the desired thickness, the mold should be picked up carefully and the excess slip poured off.

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[38]Barford, op. cit., p. 61.

[39]Ibid., p. 62.

When the interior shine has disappeared from the cast, the top edge of the form should be struck off level with the top of the mold. If this is done, that portion of the mold over which the excess slip was poured will hold the clay more tightly than will the remainder of the top edge, thus causing warpage.

A cast made in a one-piece mold may remain in the mold indefinitely. The longer it remains, the less opportunity the mold has to dry for re-use. As soon as the piece has shrunk away from the mold and seems entirely released, a plaster bat may be placed across the top of the mold and the whole inverted. The mold may be lifted carefully away from the clay form, which remains on the bat for drying or until stiff enough for handling. The mold may be re-used at once unless it is quite wet from previous castings.[40]

The Potter's Wheel

Much of the glamour of the potter's craft is associated with the wheel. Undoubtedly, the making of a model by throwing and turning on a wheel is the most fascinating of methods for making pottery. Here is where a person actually creates form - "a lifeless lump of clay takes shape under your hands to become a thing of beauty."[41]

Noone knows exactly where or by whom the potter's wheel was invented, but it would be safe to say that it is an ancient device. It was used by the Greeks, the Chinese, and people of other early civilizations. Wall paintings in Egyptian tombs show the wheel in use as far back as 2000 B.C. "It is interesting to know that the American Indians did not possess this knowledge; all their pottery was produced by the coil method, as through the use of molds."[42]

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[40] Ibid., pp. 62-63.

[41] Zarchy, op. cit., p. 59.

[42] Ibid.

Types of Potter's Wheels The potter's wheel is simply a flat disk, rigged in such a way that it can be made to turn horizontally. The kick wheel is one type of potter's wheel. The throwing head, upon which the pottery is shaped, is connected to a vertical shaft, the other end of which is fastened to a heavy flywheel. The potter stands or sits, kicking the lower wheel into motion to make the throwing head revolve. Other types of wheels are operated by foot treadles and push bars. In all cases, the principle is the same: a heavy flywheel is set in motion by foot action, and this causes the throwing head to turn steadily.

Many of the new potter's wheels are motorized. An electric motor is connected to the wheel through reducing gears or pulleys, so that the head will revolve at a slow speed. A wooden or metal bar is depressed by foot to speed up the wheel; releasing the foot pressure allows it to slow down.

A commercially made potter's wheel usually has a metal head, which is screwed to the shaft. Advanced ceramists can shape a piece of pottery directly upon the metal head, then cut it loose with a wire and remove it.[43]

Throwing and Turning

Throwing is a term used to describe the technique of building a ware with the aid of the wheel. Turning refers to the finishing and smoothing of the ware with tools after the clay has dried to a leather-hard stage. Since the clay must harden before it can be turned, it is not possible to finish a piece in one sitting.[44]

It is difficult to describe these operations. The best way to master the wheel is by watching an experienced potter at work and then practicing on

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[43] Ibid., pp. 59-61.

[44] Engel, op. cit., p. 75.

your own. There are a thousand and one little tricks in the position of the arms, hands, thumbs, and fingers which are impossible to describe but which can easily be learned by watching an expert throw and turn.

A beginning ceramist cannot expect to become an expert with the potter's wheel overnight. It requires much practice. However, there is no reason why a person shouldn't develop enough facility with the wheel to produce excellent wares after a while. All it takes is patience and determination, and the result is more than worth the effort.

Ceramic Sculpture

"Ever since man began to make objects from clay, thousands of years ago, ceramic sculpture has been a favorite means of artistic expression. Museums exhibit the wonderful clay animals and figures of ancient Egypt, the horses and riders of Crete, the tanagra figurines of Greece, and the work of the ancient Mexican and Peruvian sculptors."[45]

As a method of creative expression, clay sculpture bows to no other medium. There are many ways of working with clay to create ceramic sculpture, from the simple push-pull method to the complex hollow-built methods. Almost any clay or clay body can be used for ceramic sculpture, although a body prepared specifically for the purpose, sold as "Terra Cotta Clay" or "Sculpture Clay" is better. These bodies contain large amounts of grog - crushed, fired clay - which facilitates stiffening during building and easier drying and firing, with less cracking. In addition, the texture of the fired clay is peculiarly suitable for sculpture. Lacking a prepared sculpture body, ordinary clay can have the same qualities through the simple addition of grog, purchased from a ceramic supplier or prepared by crushing

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[45]Barford, _op. cit._, p. 86.

lightweight insulating brick, which can be wedged into the clay. Dampening the grog before wedging will prevent the clay from becoming stiff, as the grog will pull moisture from the clay otherwise.[46]

With ceramic sculpture, one is not bound by conventional ideas, but rather the imagination is allowed to work freely. If the sculpture doesn't turn out the way you would like it to, you can always break up the clay and use it to start afresh.

The design of the sculptured piece should be determined by the nature of the material being worked. Clay has certain characteristics that must be respected. (When fired, it is hard, but it can be shattered easily.) Avoid sharp corners, for they aren't sound ceramic design, corners chip easily. For the same reason, it is not recommended to make a piece with thin, projecting parts that can be snapped off. If a part of the sculpture must protrude, make it solid and strong. Work all over the piece at once. Model the general form before any attention is given to detail. Use plaster clay for modeling. If it is soft, two pieces can be joined by pressing and rubbing them together. If the clay is even slightly hard, this won't be possible, for the two joined sections will fall apart when the piece is dried and fired. Slip must be used as a cement. The surfaces to be joined are prepared by scoring them with a knife. Once they have been roughened, they are coated with slip and quickly pressed together.[47]

There is a definite technique to follow when preparing pieces that are to be fired. A figure cannot be simply modeled and left in solid form, for it may break up during firing. Clay sculpture pieces should be made hollow,

[46] Ibid., pp. 86-87.

[47] Zarchy, op. cit., p. 77.

with walls not more than one inch thick. Small figures may be hollowed by scooping out the excess clay, with a spoon, for example. When making a head, the clay may be removed through the bottom of the neck. A simple way to hollow a figure is to model it around a core of wadded newspaper. As the piece is fired, the paper will burn away, leaving it hollow. The paper core is usually left exposed at the underside of the figure. A clay figure can also be built around a ball of twine. Allow the clay to become leather-hard, then pull the twine and unravel the ball. This leaves a hollow figure. Still another way to hollow a figure is to model it solidly first, then cut it in half, scoop the clay out of each part, and join the hollow halves with slip.[48]

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[48] Ibid., pp. 78-80.

CHAPTER III

CERAMIC FIRING AND DECORATING

Bisque Firing

The term raw or greenware is applied to a piece of clay that has been shaped and dried. Clay in this state is fragile and impermanent. If it were immersed in water, it would soon become soft and eventually lose its shape entirely. Greenware is hardened by firing it in a special oven called a kiln, pronounced "kill." Greenware must be thoroughly dried before it is fired. Even though a piece may appear absolutely dry, it contains water. Some of this water is combined with the clay chemically, and some of it is water that has been added to make the clay plastic. Thick pieces in particular can be very deceptive; the outer layer of clay will dry, leaving the inside quite moist. One of the better ways to dry greenware is to allow it to dry naturally in a warm, well-ventilated room. After this, artificial heat may be applied to complete the process, such as with the use of an infra-red lamp.[49]

When a clay piece is thoroughly dry, it is ready for the kiln for firing. After it has been fired once, it is known as "bisque," or biscuit ware. It has become hard and dense, and its color has changed from gray to white, buff, pink, or red, depending on the type of clay used. After the pieces have been bisqued fired they are then ready for glazing, which

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[49]Zarchy, op. cit., pp. 86-87.

will be discussed later. Sculpture is often considered finished in the bisque state, particularly executed in terra cotta or sculpture clay.

Kilns

As mentioned previously, clay pieces are fired, or hardened, in a kiln. There are many sizes and kinds of kilns used today. However, the four main essentials which must be present in all kilns are the same. There must be a means for producing heat, a support for the ware to be fired (kiln "furniture" - shelving and shelf supports), a wall to contain the heat (insulating material), and a means for transferring the heat from its sources to the ware (heating elements).[50]

Studio or school kilns are usually heated (fired) by either electricity, gas, or oil. The electric kilns are recommended for most school situations because they are more simply operated and they are generally safer to use than the gas or oil type. Electric kilns have the advantage of being easily installed wherever current is available. Unlike gas and oil kilns, electric kilns do not require near as many vents or chimney outlets. They provide clean, odorless heat, and are inexpensive to operate.

Oil and gas fired kilns may be built to withstand extremely high temperatures, the only limit being the type of refractory (heat-resisting) brick and insulating material used in their construction. Porcelain, which must be fired at a high temperature can be handled in kilns of this type.

Kilns are available in either top or side-loading models with either low-fire or high-fire elements (2000 degrees, Fahrenheit, or 2300 degrees, Fahrenheit). The fire, or heating elements of a kiln are generally of two types: Nichrome and Kanthal. Kilns that use Kanthal heating elements can

[50]Engel, op. cit., p. 108.

withstand the higher temperatures.[51]

There are simple rules to follow in the care and maintenance of kilns. These rules can be found in the Appendix D, page 65.

If a kiln is being used for the first time, it is recommended that the inside be given a coat of "kiln wash." This is a powder, composed of equal parts of flint and china; it is mixed with water to make a creamy slip, and can be applied with a brush. It is important that it is kept off the heating elements, or it will shorten their life. The kiln wash coats the refactory brick which forms the inside of the kiln, and prevents it from rusting off onto the ware during firing. Fire the kiln for about two hours with the door partly open. This will drive off all the moisture ready for use after it has cooled.[52]

It is particularly important that the refactory brick be coated with kiln wash during glaze firing. Kiln wash will protect the walls from the action of volatile glazes. Should glaze drip from the ware and harden on the floor of the kiln, it will stick to the wash coating, from which it can be removed very easily.

During firing of a kiln, the temperatures are indicated by the use of pyrometric cones or a pyrometer. Pyrometric cones are small, slender triangles, made of ceramic materials (carefully compounded of clay and fluxes). They are designed to melt or bend at definite temperatures, and are numbered so that they may be identified. Cones are made in a wide range of melting points from cone 922 (1085 degrees, Fahrenheit), to cone 42 (3659 degrees, Fahrenheit). (See the Appendix C, page 64 for temperature equivalents of standard pyrometric cones.)

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[51] Zarchy, op. cit., pp. 89-91.

[52] Ibid., p. 91.

> The most accurate method of using cones consists of using a group of three cones. For instance, if the desired temperature is cone 04, place a base (clay and grog) with three cones reading 03, 04, and 05 in position behind the spyhold of the kiln. When cone 05 melts, you will be alerted for the bending of cone 04 and you will be able to catch it in time. Cone 03 will indicate a heat rise beyond cone 04. In an electric kiln, the heat drops immediately when the current is cut off. Since heat tends to rise in an electric kiln, it may be necessary to turn the top controls to medium when the top cone melts. Leaving the bottom section on high will allow heat to build up in the lower part of the kiln. This is especially important if a shelf is placed near the bottom. In large, gas kilns, however, the heat may rise slightly in some sections after the fuel has been turned off and the draft closed, because greater heat is produced in the firebox and is soaked up into the chamber above.[53]

Some kilns are equipped with pyrometers, from which temperatures may be read directly. "It is advisable to check the pyrometer on a new kiln by placing cones within the kiln, to ascertain whether the pyrometer is providing an accurate reading. If it is, then the pyrometer alone may be relied upon."[54]

Preparing and Stacking the Kiln for Firing

Preparing and stacking a kiln for bisque firing is relatively easy. The ware may be placed directly upon the bottom of the kiln and on the shelves. Pieces may be placed inside one another for space economy, and pieces may touch each other unless they have been decorated with engobe, slip, or underglaze that has enough fluxing material present to permit some fusion. They should, however, be kept at least one inch away from the heating elements of any electric kiln.[55]

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[53]Nelson, op. cit., p. 91.

[54]Barford, op. cit., p. 109.

[55]Ibid., p. 108.

Generally speaking, large sculptured pieces are stacked separately. The chance of such a piece chipping or breaking in the kiln is greater and this may destroy other ware in the kiln. Before it is fired, a piece of sculpture should have a minimum drying time of six weeks.[56]

It is a basic law of physics that hot air always rises, cool air always sinks. Thus, the lower half of the kiln is always cooler than the top. This makes it necessary, when loading a bisque fire, to place the heavier, thicker pieces on the bottom or cooler area of the kiln. These pieces are more likely to be ruined by sudden changes in temperature than are the thinner wares.

When placing the heavier, thicker pieces on the floor of the kiln, leave room in the corners for four posts which are about 1" taller than the tallest piece of greenware. Gently lower the shelf in place atop the supports. Stack more ware on the shelf. As many shelves as space permits may be stacked in the kiln. In the case the kiln being used is not equipped with a pyrometer, place the pyrometric cones on one of the shelves where they can be clearly seen through the spyhole in front of the kiln.

The ware should be stacked in such a manner that the hot air can circulate freely through the kiln. Passages should be left open from the top to the bottom of the kiln and from side to side to give the kiln a chance to heat evenly. Otherwise, some of the ware will come out hard and properly matured and some will come out soft and have to be refired.[57]

Bisque Firing Schedule

Once the kiln has been stacked, it is ready for firing. The following

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[56]Engel, op. cit., p. 118.

[57]Ibid., pp. 117-118.

procedure is given for using an electric kiln, but the procedure is the same regardless what fuel is used. With respect to the size of the kiln used, the exact time for each firing stage will vary. Larger kilns will need more time to develop clay-maturing temperatures.

Bisque firing should be started at a relatively low heat. Open the spyhole; leave the door open a crack; turn the switch to "low" heat. Keep the temperature at about 500 to 600 degrees, Fahrenheit, for an hour or two. This period of firing is called water-smoking or "water out." If the heat were increased too rapidly at the start, the moisture would turn to steam and would blow up the stacked ware in the kiln. Sudden high heat may also cause warping or cracking.

The next step is to turn the switch to "medium" heat; shut the door, but leave the spyhole open; fire for an hour or two. Hold a mirror or glazed tile up against the spyhole opening. If it becomes cloudy, moisture or water smoke, is still escaping. When the mirror or glazed tile does not become steamed, this is an indication that all the moisture has been driven out. When this happens, the kiln should be sealed tightly.

Turn the switch to "high" heat and fire the ware until maturing point. The kiln should then be turned off and allowed to cool. Do not open the kiln immediately after turning off the power. A general rule is not to open the kiln until twice the firing time has elapsed. The kiln is insulated very efficiently so that it can retain the heat that it builds up during firing. This also prevents the heat from escaping rapidly while it cools. Slow cooling permits the ware to shrink back to its normal size without distortion or cracking. If a piece is chilled rapidly, it may break, warp, or develop internal stresses and later it may shatter for no apparent reason.

When the cooling time has elapsed, unplug the spyhole and open the door no more than an inch or so. Open it a bit more at intervals of fifteen minutes, until finally it is completely open. Wait at least an hour before removing the fired bisque from the kiln so that the pieces can be handled comfortably without gloves.[58] (General rules for bisque firing; see the Appendix E, page 66.)

Decoration

The terms "decoration" and "surface enrichment" are often used interchangeably in ceramics. Regardless what term is used, the meaning exists to enhance the form of a particular ceramics piece, to make it more attractive and pleasing to the eye.

> The earliest form of surface enrichment on clay shapes was undoubtedly accidental. Clay bowls discovered on the sides of prehistoric Swiss Lake villages were found to have marks of basketry on the outside, implying that the bowls were shaped by smearing clay on the insides of baskets, then burning away the basket in the process of firing the pottery.[59]

When man began decorating clay objects consciously, his first tools were his fingers or crude sticks. The decorations were simple stripes or cross-hatchings, reminiscent of his earlier pieces made within baskets. Later, the complexity through the use of variously colored clays, applied in strong contrast to the colors of the clay pieces themselves.[60]

With the discovery and use of glazes, further surface enrichment and more sophistication were possible, but for thousands of years, pottery decoration depended on either colored clays, slip decoration, or on pressing and incising. These methods are widely used in contemporary ceramic work.

There are several methods of decorating ceramic ware, some of which will be discussed in the few following pages. Depending upon the method used,

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[59]Barford, _op. cit._, p. 66.

[60]_Ibid._

decoration may be applied when the ware is either leather-hard, bisque fired or even glazed.

Ceramic Colors

Paints cannot be used in ceramic work which is to be fired. The high temperatures used when firing will burn out the materials of which they are composed. Therefore, special ceramic colors made with mineral oxides are used instead. These are mostly gray or black, but will turn a distinctive color when fired to the proper temperature. They do not actually mature like clay, but are used together with clay and glazes to give them color.[61] The following list shows a few of the oxides which are commonly used as coloring agents, together with the colors they make:

Mineral Oxide	Color
Antimony oxide	Yellow
Cobalt oxide	Blue, black
Copper oxide	Green
Iron oxide	Brown
Manganese oxide	Brown, black
Nickel oxide	Blue, green

Engobe or Slip Painting

Engobe is colored slip. "This term derived from 'Envelope' at a time when a contrasting slip was used to cover an entire form, with the intention of presenting a more pleasing appearance than did the coarser clay of which the form was made."[62] Today, engobes may be bought in liquid form ready for use. However, you can make your own by simply adding ceramic colors to slip. (See Appendix A, page 61 ; mixture for making colored slip.)

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[61]Zarchy, *op. cit.*, pp. 98-99.

[62]Barford, *op. cit.*, p. 70.

Decorating with slip is relatively easy. The slip is merely brushed directly onto the surface of the leather-hard (unfired) ware. It may be brushed on using an artist's soft water color-brush. "Don't brush over and over the same area, but try to work with a loaded brush, so that a thick coating is applied with one stroke. Allow the piece to harden, after which it may be bisque fired, coated with transparent glaze, and fired a second time."[63]

Ceramic ware may be decorated with slip made from a clay body that is darker or lighter than that from which the piece is made. Sometimes this slip decoration may chip, or crack off because of a difference in the shrinkage rate between the clay in the ware and the slip that has been painted on. This can be avoided by making engobe from the same clay of which the piece is formed.[64]

For the beginning ceramist, it is best to buy engobes already prepared for use. Commercially prepared engobes are available in a greater range of colors than can be prepared.

Sgraffito is another form of engobe decoration. First, the leather-hard ware is completely coated with contrasting slip. This may be done by using a brush, or by dipping the piece into a large container of slip. A design is then scratched through the slip coating, so that the body of the ware shows through. A sharp-pointed instrument such as a nut pick, a metal scriber, or a thin knife point. Burrs are created by cutting but they brush off readily when the sgraffito process is complete.

Underglaze and Overglaze Painting

The most commonly used forms of decoration are "underglazing" and "over-

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[63]Zarchy, op. cit., p. 99.

[64]Ibid., p. 100.

glazing". Underglaze decoration includes any ornamentation that is applied to ware before it is glazed and fired. This includes slip-painting and sgraffito carving or any color painting done on greenware or bisque. For example, if a floral design were painted on a piece of greenware, then covered with a clear glaze and fired, it would be a typical form of underglazed decoration.

Ornamentation applied after the ware is glazed is called overglaze decoration. The two most popular forms of overglaze decoration are hand-painting with overglaze colors and the use of decalcamanias, or decals.

The main difference between underglaze and overglaze colors is that the former are not fusible. That is, they (underglaze) will not adhere to the ware even if fired. They will still be a powder and will rub off. Therefore, glaze is necessary to hold the colors in place and keep them from smearing. Underglaze colors consist of one-third metallic oxide, one-third slip, and one-third glaze. A note of caution is to make certain that the slip in the paint is the same clay as that in the piece to be decorated so it will have the same shrinkage in the kiln. The glaze in the color must also be the same glaze that will be used over the underglaze paint.[65]

Although underglaze colors can be made in the classroom or home workshop, it is much more prudent for the novice to buy them already prepared. They may be purchased from ceramic suppliers and may be obtained in five forms, dry powder; moist, ready-to-use; semi-moist; in pans; crayons; and pencils. If purchased in dry form, the colors must be mixed with water, a few drops of glycerine or gum solution to aid in brush ability and, if desired, a small amount of frit or transparent glaze to act as a binder in firing.[66]

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[65]Engel, op. cit., p. 89.

[66]Barford, op. cit., p. 77.

Overglaze colors are actually low-fire glazes, which mature at a lower temperature than the glaze used on the body of the piece that is being decorated. Overglaze colors are applied to light surfaces, generally with a very soft camel's-hair brush. The colors are not absorbed by the ware, but remain on the surface. This makes it difficult to paint one color over another as the application of the second color usually smears the one underneath. Once the basic design has been brushed on, the colors are allowed to dry, and the piece is fired. When using commercial overglazes, always check the manufacturer's recommendations for the firing temperatures because all overglazes do not mature at the same temperature.

There is actually no limit to the number of tonal and color combinations that can be obtained with overglaze, because you can apply one color over another, and fire the piece as many times as desired.[67]

Incising, Inclaying, Embossing, and Banding

There are various other methods of decorating in addition to the ones already mentioned. The following are a few methods that the writer feels should be mentioned under the heading of ceramic decorations.

Incised designs are made by scraping a tool point across the surface of moist or leather-hard clay. Any fairly sharp tool that will cut a fine groove in the clay may be used. It is important that the piece be moist or leather-hard while working on it. If it should dry out, it can be restored by spraying it with water, covering it with a damp cloth, and placing it in an air-tight container for a few days.

It is sometimes best to plan the design on paper, then transfer it to the clay by tracing it with a sharp pencil. The design may also be scratched

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[67]Zarchy, op. cit., pp. 103-105.

directly onto the clay. "After the design has been completed, the piece is allowed to become bone dry. It may be then glazed and fired in a single operation, or you may bisque fire it before the glaze is applied. The incised lines will show up very well, because the glaze will pool up in them and fire out darker."[68]

Inlaying is a technique of decorating ceramic ware where by the design itself is cut out of the leather-hard body, leaving a recess. This space is then filled with a clay body of a contrasting color. Another way of inlaying is to cut out a recess, then pressing small pieces of colored clay into it, until it is filled. Inlaying may also be done by incising lines and filling them with thick colored slip.

Embossing is a type of decoration in which clay ornament is added to the ceramic piece while it is still in a leather-hard state. Slip is used as a bonding agent. Clay may not necessarily have to be modeled before it is attached to the piece; it may be fastened in place and then modeled. After the decoration has been designed, the piece is allowed to dry thoroughly and then fired.

Banding is a technique used to point horizontal stripes of color on pottery. This is generally done with the aid of a potter's wheel. A soft pointed brush is then loaded with the decorating medium (colored slip, underglaze color, overglaze color, etc.). The wheel is set in motion, and the brush is touched lightly to the revolving ware. The result should be a perfectly horizontal stripe.

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[68] Ibid., p. 107.

Glazing

Throughout this paper the term "glazed" has been used time and time again and by now the reader probably has a fairly accurate understanding of what the term means. Nevertheless, we shall now investigate glazes and glazing techniques in further detail.

It has been mentioned previously that a glaze is a thin sheet of glassy material which covers and adheres to an object made of clay. Glazes serve two major functions: utilitarian and decorative. In pottery, the glaze gives a smooth surface, prevents food and water from being absorbed by the clay, and is more easily cleaned. Glazing also gives a more pleasing color and texture than the clay and adds greatly to the beauty of the piece. In sculpture, glazes are not necessary for practical purposes, but sometimes they increase the excitement and interest of such an art object.

> Glazes are not paints. They are glass-like coatings, made of combinations of chemicals known as silicates. When fired to the proper temperature, they fuse, or melt. However, a good glaze is more than a mixture of chemicals that melt when it is fired. It is carefully compounded so that it possesses other characteristics as well. In the first place, its melting point must be lower than that of the clay body to which it is applied. It must flow, under heat, yet it should not become so fluid that it runs off the clay body. The mature glaze should show the proper color and texture. Finally, it must fit the clay body it covers, so that it does not develop cracks.[69]

Kinds of Glazes

Glazes may be broken down into two groups: bright glazes and matt glazes.

Bright glazes are those with a shiny, glossy surface.. They may be transparent, or opaque. As mentioned earlier in this study, colorless, transparent

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[69] Ibid., p. 112.

glazes are used over underglaze colors. Since they have no color of their own, the underglaze decoration is not affected. Bright glazes are sometimes known as majolica glazes. Glazes in this group flow freely during firing, and level off to a smooth surface. Opaque glazes may be used on any body, as the clay underneath will not show through.

Matt glazes fire out with a dull, velvety texture. Unlike gloss glazes, they flow very little, or not at all, during firing. Therefore, matt glazes are applied in a heavier coating than gloss glazes. Unless care is taken to apply them evenly, defects will show up in the fired piece.[70]

There are various types of commercial glazes made in many interesting textures. (See Appendix B, page 62.) Certain glazes may have a "crystalline" structure, or may fire out with a fine, "crackled" surface. Other glazes are designed to give rough, stonelike effects, and others show unusual mottlings of color and texture.[71]

Although ceramic glazes may be prepared in the classroom or home workshop, the novice ceramist is much better off buying them ready made. When a ready made glaze is used as recommended, one can be fairly certain of the results. However, one important note should be made: not all glazes work well on all clay bodies. The glaze must mature at the same temperature as the clay, or even at a lower temperature, but never higher. Both the clay and the glaze contract as they cool after firing. Should their rate of contraction differ, the glaze may turn out to be too small or too large for the piece. Therefore, it is advisable to purchase clay and glaze products by the same manufacturer since they know their products well, and can recommend which of their clay bodies and glazes should be used together.[72]

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[70] Ibid., pp. 112-113.

[71] Ibid., pp. 113-114.

[72] Ibid., p. 115.

Applying Glazes

Glazes may be applied to pottery and ceramic sculpture pieces by various methods. The most commonly used methods are brushing, spraying, pouring, and dipping.

Applying glaze by brush is a simple method and requires the smallest amount of glaze. Care has to be taken, however, to insure an even coating. A soft, wide brush should be used to apply the glaze with even, slightly overlapping strokes in one direction, followed by a second coat at right angles to the first, then finished with a third coat in the original direction.[73]

Glaze spraying requires certain necessary equipment: a spray booth with an exhaust fan, a spray gun, a supply of air pressure and a simple turntable on which to revolve the ware. The advantages of glaze spraying are the even coating which can be achieved and the ease with which one glaze may be applied over another. The disadvantages are the equipment and space required and the maintenance of the equipment.

The pouring method of glazing may be used on both the interior and exterior surfaces of a ceramic form. When glazing pottery, "the inside is glazed first, by filling the piece to about the half-way point, then emptying into a clean container immediately, rolling the form in at least one full revolution as it is inverted."[74] The excess glaze will pour out the lip of the form at the end of the rotation, leaving an even coating within. The process must be done rather quickly or the glaze will become very thick on the inside. For glazing the outside of the form, merely support it on two sticks placed parallel across the rim of a bowl and pour the glaze over. One note should be made: glaze for pouring should be thin enough to pour readily. If it is too

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[73] Barford, op. cit., p. 102.

[74] Ibid., p. 103.

thick, the glaze coating on the absorbent bisque surface will become too heavy, even though the process is carried out with some speed.

Dipping is a quick method of glazing. However, it requires more skill and a larger quantity of glaze than the other methods mentioned. In this process, the entire form must be passed, or dipped, through a container of liquid glaze. A proper relationship between the consistency of the glaze, the porosity of the ware, and the speed of dipping is necessary. Very porous bisque should be dipped more quickly and in thinner glaze than dense ware, since it will take on the glaze much more rapidly.[75]

Regardless which method of applying glaze to bisque forms is used, it is important that the form be clean before glaze is applied. All surfaces should be wiped with a damp sponge or momentarily placed under a water tap to remove dust and loose particles of clay. The bisque ware should not be handled excessively. Hands contain natural oils and these oils will repel glaze.

Stacking the Kiln for Firing

Glazed pieces should be allowed to dry before stacking, or at least before starting the kiln.

When using an electric kiln for glost (glaze) firing, it is recommended that the heating elements be cleaned with a soft brush. This is to avoid any possibility of small black specks depositing on the forms during firing. In addition, the interior of the kiln should be coated with kiln wash along with the kiln furniture (shelves, props, and stilts).

It was mentioned earlier in this paper that pieces to be bisque fired may touch one another and even be placed within one another in the kiln. This

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[75]Barford, op. cit., p. 103.

cannot be done in the glost fire, for the pieces will stick together. Each piece to be glazed must be separated at least ½". Furthermore, pieces should not overhang one another. During the firing, glaze may drip down and spoil the piece underneath. Pieces should be stacked at least 1" away from the heating elements and the walls of the kiln.

Unlike stacking a kiln for bisque firing, pieces are placed on kiln furniture rather than directly on the base of the kiln or the shelves. This is so that when the glaze flows during firing, the piece will adhere to the furniture rather than to the shelf or kiln floor. The furniture may be carefully chipped off the pieces after firing. Round bottom ware is generally supported on "stilts". "Spurs", "saddles", and "bars" are other kiln furniture articles used for stacking glaze pieces.

<u>Glaze Firing</u>

After the kiln has been properly stacked and the proper pyrometric cones have been aligned with the spyhole of the kiln, the glost fire is ready to be performed.

The firing schedule is basically the same as previously described for bisque firing. Again, the firing time will vary with the size of the kiln used. The following schedule is for a small electric kiln:

1. Open the spyhole; leave the door open a crack; turn the switch to "low" heat; fire for one hour.
2. Turn the switch to "medium" heat; shut the door, but leave the peephole open; fire for one hour.
3. Turn the switch to "high" heat; fire ware to maturing point.[76]

Leave the spyhole open until the ware in the kiln glows red. Close the spyhole. After several hours, examine the cones at fifteen minute intervals.

[76]Zarchy, op. cit., p. 128.

When the middle cone goes down, check every five minutes and shut off the kiln as soon as the middle (maturing) cone begins to bend. Allow the kiln to cool before the door is opened (allow twice the firing time to elapse before opening the door). Open the kiln door an inch or two every fifteen minutes until it has been opened completely. Wait until the pieces are cool before removing them from the kiln.

Grinding Glazed Edges

Almost without exception, during firing, as the glaze matures and flows, it hardens around the point of the stilt, spur or whatever kiln furniture is used to carry the piece. When the piece is removed from the kiln, the stilt or spur is broken away. The points or portions that remain are then ground off, leaving a smooth surface. Grinding may be done with a power grinder or with a hand grinder. The important thing is to grind the surface smooth.

Glaze Defects

It is not uncommon to have several defective ceramic pieces in a single glaze firing. Sometimes glazes will "crawl", "blister", "fade", etc. . . The following is a list of common glaze defects and their probable causes:

Blisters - These are caused by dirty bisque, or the presence of sulphur in the clay body; may also be caused by under-fired glazes - refired at the next higher cone.

Crawling or Bare Spots - Glaze was applied over fingerprints, or dirty spots; glaze sometimes pulls away from underglaze colors that have been applied too thick.

Crazing - This may be caused to too rapid cooling of glazed ware, by a glaze that does not fit the clay body, slightly under-fired glaze, or bisque made too porous by underfiring.

Dark Spots - These are usually caused by tiny particles of metal that have somehow gotten into the clay body or the glaze. It is recommended that glazes be kept out of metal containers, and that the heating elements of the kiln, before firing, be cleaned.

Discoloration - When ware is fired too close to the heating elements of the kiln, it may be partially discolored.

Dry Spots - Dry, rough areas indicate that too little glaze has been applied; the piece may be reglazed and fired.

Matt Glazes Fire Out Bright - This may be caused by over-firing too rapid cooling, or a glaze application that is too thin. Reglaze and refire.

Pin Holes - Tiny holes in the ware are caused by air bubbles; air trapped in the clay causes holes in the bisque and these remain open after glazing. Wedge clay thoroughly before use; casting slip should be aged before use, and poured carefully to avoid bubbles.

Colors Run - Underglaze colors have been applied too thick; glaze may be too thick; glaze fire may be too high.

Smudged Underglaze - Underglaze colors have been disturbed during the glaze application, usually by brushing; glaze should be sprayed on.

Faded Overglaze Colors - Overglaze colors have been burned out. Use pyrometric cones, or a heat-indicating pyrometer.

CHAPTER IV

SUMMARY

Ceramics is an extremely old and rich craft and may be commended for its many contributions to our past and present day civilizations. The history and development of the craft point out the fact that ancient people developed ceramic ware as a utilitarian necessity, but it also developed into an art and means of expression. It has survived more than 5,000 years and continues to supply many opportunities for learning and self expression today.

Many innovations have contributed immensely to the continued increase of interest in this craft for the people of today. People of all types are taking advantage of its many practical applications. Industry, schools, hospitals, therapeutic clinics, and recreation are of the major areas of application.

The methods and techniques of ceramic construction indicate that anyone may pursue the craft and achieve a measure of success. Only a person's imagination will limit the possibilities. When a ceramic article is fired properly, it is converted into one of the most permanent of ordinary things. When it is shaped with imagination and skill, it can become a work of exquisite beauty. Despite the many contemporary innovations (easy-to-apply colors and glazes, electric kilns, prepared clays) enjoyed by ceramists today, the basic methods of ceramic construction have not changed since the days of prehistoric man. They have been improved, embellished, but not essentially changed.

Various methods of decoration and the effects of glaze and color make ceramics potentially the richest of all crafts. In addition to its utilitarian function, glazes give a more pleasing color and texture than the fired clay and adds greatly to the beauty of the piece. In sculpture, glazes are not necessary for practical purposes, but sometimes they increase the excitement and interest of such an art object.

The past and present status of ceramics has been presented, but the future provides the opportunity for further growth of this craft. The acknowledgement is made that there has been no attempt to cover ceramics in its entirety, but rather a superficial overview of the craft has been presented. The trends noted by the writer indicate that in the years to come we can look forward to ceramics as a continuing interesting and challenging craft.

SELECTED GLOSSARY

BALL CLAY - A naturally occurring, extremely plastic clay that is usually mixed with other clays to make them more plastic.
BISQUE or BISCUIT WARE - Underglazed but fired clay-ware; pottery after first firing but before glazing.
BONE CHINA - A type of soft porcelain containing calcined bones.
CASTING - Making pottery by pouring clay slip into plaster molds.
CHINA - A term loosely used when referring to dinner ware. It originally meant porcelain that came from China.
CHINA CLAY - Kaolin, or white clay formed by the disintegration of igneous rock.
CONE - A slender pyramid composed of special clay bodies, designed to melt at a specific temperature.
CRACKLE - A fine network of cracks deliberately produced in a glaze to give it an antiqued appearance.
CRAWLING - Said of glaze that does not flow out evenly, but gathers in lumps, leaving bare spots.
CRAZING - Unintentional cracking of the glaze caused by unequal shrinkage of the clay body and the glaze.
DEFLOCCULANT - Electrolytes added to slip to prepare it for casting, usually sodium silicate and sodium carbonate.
DRAWING - Removing ware from the kiln after it has been fired.
EARTHENWARE - Soft, porous pottery fired at low temperatures.
EMBOSSING - Decorating ceramic ware with raised clay ornamentation.
ENGOBE - Colored clay slip used as decoration.
FETTLE - To remove mold marks from cast pieces.
FIRING - Heating ceramic ware to its maturing point.
FRIT - An insoluble, finely-ground, glass-like substance used in certain types of glazes.
GLAZE - A glassy coating applied to ceramic ware.
GLOST - Referring to the glaze firing.
GREENWARE - Unfired ware.
GROG - Bisque ware that has been crushed and ground; it is often added to clay to give it strength and prevent warping.
INCISING - The process of decorating a clay surface by cutting into it.
KAOLIN - China clay, a white-bodied clay that is one of the principal ingredients of porcelain.
KILN - An oven or furnace in which ceramic ware is fired.
KILN WASH - A mixture of powdered flint and kaolin, used as a protective coating inside the kiln.
MAJOLICA - Originally applied to a type of pottery coated with an opaque enamel glaze with a tin base, supposed to have come from the island of Majorca; now generally understood to refer to any opaque glaze with a high gloss.
MATT - A non-glossy glaze with a soft, velvety texture.
OVERGLAZE - Low-fire glaze applied as decoration over a harder glaze.
OXIDES - Metallic compounds used as coloring agents in ceramic work.
PEEPHOLE or SPYHOLE - A small window in the door of a kiln, through which the ware may be observed during firing.

PORCELAIN - Hard, translucent, white ware that is generally made from a paste composed of feldspar, kaolin, and flint. It is highly fired and very vitreous, and is considered the finest type of ceramic ware.

PYROMETER - A temperature-indicating device consisting of a thermocouple, and a sensitive electric meter.

RAW CLAY - Clay as found in nature; not blended with other clay bodies.

RAW GLAZE - A glaze composed of ingredients which are all insoluble in water and do not require fritting.

RAW WARE - Ware that has been shaped and dried, but has not been fired; greenware.

REFRACTORY - Infusable; heat-resistant; difficult to melt or soften.

SADDLE - A triangular bar made of refractory clay, used to support ware in the kiln during firing.

SGRAFFITO - A method of decorating in which lines are cut or scratched through a layer of slip or overglaze color, exposing a contrasting clay body underneath.

SLIP - Liquid clay.

SPUR - A small, pointed, fireclay support for glazed pieces.

STACKING - Loading a kiln for firing.

STILT - A three-pronged fireclay support used under ware that is being glazed.

STONEWARE - A highly fired, vitrified type of gray or brown ware with a coarse, flinty texture.

TERRA COTTA - Unglazed pottery; usually refers to sculpture.

THROWING - Finishing greenware on the potter's wheel by cutting or shaving it with a tool.

UNDERGLAZE - Ceramic colors used for decorating greenware or bisque before glazing.

WEDGING - Cutting, then pounding or kneading clay to remove air bubbles and bring the mass to an even consistency.

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APPENDIX

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APPENDIX A

TABLE FOR MAKING COLORED ENGOBES

The following table is based on level spoon measurements per pint of liquid slip. The amounts of oxides given are approximate, as the resulting fired colors will vary according to the type of clay body used in preparing the slips and the types of glazes used over them.

LIGHT BLUE	3/4	teaspoon cobalt (oxide or carbonate)
MEDIUM BLUE	1¼	teaspoon cobalt
DARK BLUE	2	teaspoons cobalt
LIGHT GREEN	¼	teaspoon cobalt and ½ teaspoon chrome
MEDIUM GREEN	½	teaspoon cobalt and 1 teaspoon chrome
DARK GREEN	1	teaspoon cobalt and 2 teaspoons chrome
PINK	3	teaspoons iron oxide
GRAY	3/4	teaspoon cobalt and 2 teaspoons manganese
BEIGE	3	teaspoons manganese
DARK BROWN	9	teaspoons manganese
BLACK	9	teaspoons mangenese and 2 teaspoons cobalt
RED-BROWN	8	teaspoons iron (or use a red-burning clay)

APPENDIX B

COMMERCIAL GLAZES

The following is a listing of some of the many types of glazes offered by ceramic suppliers. It also serves as an abbreviated "dictionary" of glaze types:

1. CLEAR TRANSPARENT GLAZE. A most useful glaze for simple projects in which decoration with colored slips or underglaze is included.

2. COLORED TRANSPARENT GLAZES. These, also, can be used over colored slips and are especially effective over carved or pressed treatments on clays firing white or light buff.

3. SEMI-MATT GLAZES. These glazes are usually opaque and have a satin texture if fired to their prescribed temperatures. Depending upon the degree of opacity, engobe decorations may or may not be visible through these glazes.

4. MATT GLAZES. These are even more opaque and drier of surface than the semi-matts. This does not mean that the surfaces are unpleasant to the touch; they are simply less shiny than other glazes. They obscure all but the strongest decorating colors used under them.

5. CRACKLE GLAZES. Usually considered a defect in a glaze, a crackle (network of small cracks) is sometimes used as a decoration in itself. The pattern can be made more prominent by rubbing black underglaze or India ink over the surface, then wiping away the excess.

6. MAJOLICA GLAZE. These are opaque glossy glazes, designed to flow freely during the firing. They are offered in many colors and should not be confused with the white (or light-firing) shiny glaze that is often referred to as "majolica base glaze," and is intended for use when majolica decoration is desired. The white glaze of the commercial majolica series, however, could be used in this manner if not overly fluid in the fire.

7. ALLIGATOR GLAZES. These glazes have a variegated texture which alternates between matt and glossy. They often create, by themselves, patterns of alternating colors.

8. SINGLE-FIRE GLAZES. Designed to be applied to greenware, these glazes should be used on clay that becomes vitreous at the same temperature as the glaze.

APPENDIX B
(continued)

COMMERCIAL GLAZES

9. HIGH-FIRE GLAZES. Considering the temperature range covered by commercial glazes, these are higher-firing, maturing between Cones 4 and 6. They are intended for use on bodies maturing at these temperatures and are available in a variety of matt and glossy, opaque and transparent types.

10. SELF-GLAZING ENGOBES. Half-way between a glaze and an engobe, these mixtures of colored slips and fluxes produce a non-glossy, non-running finish on pottery. Some mature at Cone 07 and are useful for sgraffito and slip painting, without a covering glaze.

APPENDIX C

TEMPERATURE EQUIVALENTS
ORTON STANDARD PYROMETRIC CONES

Cone Number	Large Cones	Small Cones
Heated at:	270° F.	540° F.
022	1112	1121
021	1137	1189
020	1175	1231
019	1261	1333
018	1323	1386
017	1377	1443
016	1458	1517
015	1479	1549
014	1540	1526
013	1566	1580
012	1623	1607
011	1641	1661
010	1641	1686
09	1693	1751
08	1751	1801
07	1803	1846
06	1830	1873
05	1915	1944
04	1940	2008
03	2014	2068
02	2048	2098
01	2079	2152
1	2109	2154
2	2124	2154
3	2134	2185
4	2167	2208
5	2185	2230
6	2232	2291
7	2264	2301
8	2305	2372
9	2336	2403
10	2381	2426

APPENDIX D

RULES TO FOLLOW IN THE CARE AND MAINTENANCE OF KILNS

1. Do not overfire. If you do not know the normal safe temperature ceiling for your kiln, write to the company that manufactured it. The firm will be glad to furnish this and any other information about the kiln.
2. Do not overload. Get circulation throughout. Set all ware so that heat may pass freely through the firing chamber.
3. Replace damaged parts. Wear invites wear. Faulty parts almost always cause poor results in the firing.
4. Do not rush the firing. Building up the temperature gradually during early stages avoids excessive strain on both the ware and the kiln.
5. The kiln should be kept free of dust at all times. Should any foreign matter reach a heating element in an electric kiln, it should be carefully removed before firing.
6. If small cracks appear on the inside walls, leave them alone. These cracks are inherent with insulating firebrick. They are not harmful in any way, since they close when the kiln is heated, due to the expansion of the material. It is the same principle as the expansion joints in sidewalks, highways, and bridges.
7. Kiln wash should be used on the top of shelves and on the kiln floor before firing ceramic glazes. It is painted on with a brush and usually consists of one-half kaolin and one-half water, mixed with water to the consistency of light cream. Kiln wash is used to prevent glaze drippings from sticking to the shelf or the kiln floor. It is not generally recommended to use kiln wash on the kiln walls.
8. Be certain that your electrical service is capable of delivering sufficient power for the kiln. Do not overload the circuit. It is wiser to install a new service which delivers more power. Your local power and light company, or your electrician, will be able to advise on the service your kiln requires.
9. Electrical connections in the kiln may in time become loose due to the effect of expansion and contraction. At any sign of excessive heat at the plug or at the terminal of the kiln, the connection should be examined. If severe blacking of the copper wire is noted, this should be shaded bright, a new connection should be made.
10. Should at any time a heating element begin to come out of the grooves, place a heating element staple at the center of the bulge and very carefully push it into the brick wall of the kiln. Caution must be used when handling the elements after the staple is in place. Fire the kiln to at least Cone 06 to soften the element and allow it to take a new set.

APPENDIX E

GENERAL RULES FOR BISQUE FIRING

1. Don't open the kiln during firing.

2. Don't fire above recommended temperatures; you may burn out the heating elements. In any case, you will certainly shorten the life of your kiln.

3. Before each firing, check the interior of the kiln for cracks; repair these with a good kiln cement.

4. Stack your kiln fully before firing. Try to fire approximately the same amount of ware each time so that your firing times will be constant. A half empty kiln may reach a high temperature more rapidly than one that is full, but that is no indication that the ware has been fired to maturity.

5. Firing will take longer on a damp day. Both the kiln and the ware absorb moisture, which must be driven off slowly.

6. Be patient. The greatest number of failures are caused by rushing the firing time and the cooling period.

APPENDIX F

OPERATION INFORMATION SHEET FOR THROWING AND TURNING ON THE POTTER'S WHEEL

The following information is taken from Gertrude Engel's book entitled How to Make Ceramics, pp. 81-82.

Throwing

The first rule of successful throwing is to make sure the clay is properly wedged. This is of utmost importance. The clay must have an even texture and be absolutely free of air bubbles and foreign matter. The smallest bubble can be enough to throw your work off. The clay should also be plastic and fairly moist. If too stiff, it will be centered only with difficulty and waste of time. If too soft, it will tend to deform when the pulling stage is reached.

When throwing, most workers fasten a plaster bat to the throwing head of the wheel, and use this as a working surface. The bat is simply lifted off when the piece is finished, and another one put in place to accommodate the next piece.

Before you begin throwing, you must check to see if the bat is both clean enough and moist enough to be used. Plunge it in water and soak it nearly to saturation. If the bat surface remains wet one minute after removing it from the water, it has soaked too long and must be dried. On a "too wet" bat, the clay slips and cannot be held in one place. If the bat is too dry, the clay will stick and cannot be removed when required. The proper dampness is achieved when the clay can be pushed along the surface of the bat without slipping too easily. Experiment and experience will tell you when the bat is properly moist.

Place a basin of water close at hand. As you throw the clay, you will have to keep it wet by splashing water on it. This will make the clay softer and easier to work while it spins. Again, experience alone can tell you how much water to use on the ware you are throwing. Too much moisture will cause the piece to collapse, too little makes shaping almost impossible.

Take a ball of well-wedged clay about three inches in diameter. In placing clay on the bat, slap it down fairly hard, as near to the center of the wheel as possible. Start the wheel spinning at a rapid speed. As the wheel is revolving, put both hands on the clay. You are now ready for the first step in throwing, called centering.

As the clay turns under your hands, you will feel its un-evenness. The object of centering is to eliminate that vibration, so that as the wheel and clay revolve there is no thumping against your fingers. Your hands on the clay will cause the rotation to slow down rapidly. But before the wheel stops spinning, remove your hands and splash water on the clay as a lubricant. Keep the wheel spinning at a consistent a speed as possible, adding water whenever you feel too much friction between the clay and your hands. Press the ball of clay firmly with both hands until you get the feel of the clay running smoothly.

Brace the left elbow against your side and, wetting the hand, press the ball of the thumb and the lower part of the palm against the clay. Keep the left foreaem rigid. Use the right hand to sprinkle water on the clay. You will notice that the clay is thus forced into the center of the wheel.

With the fingers of the right hand, pull the clay toward you, at the same time pressing inward with the left hand. As the hands come together, the clay will rise into a cone. Do not pull it upward but let it rise of its own accord as it is squeezed. Now, bring the hands over the top and with the thumbs together, press down again. Lumps and irregularities will be felt in the clay and the operations of spinning up and down must be continued until these disappear. All the time you are working with the clay, keep it liberally sprinkled with water.

If you are throwing a vase, a cylindrical shape is necessary. Always start your wheel turning before you start working with your hands and always remove your hands while the wheel is still running. If you remove your hands after the wheel has stopped, you are likely to throw the piece out of line.

Now, moisten both hands and clay. Grasp the clay lightly but with sufficient force to give you dominance over the clay. You will find it helpful to steady your hands some way. Brace your elbows against your hips, or use arm supports if necessary. Do not bend your wrists.

Encircle the clay with your hands. Press the right thumb firmly toward the palm to form a cup-shaped hollow. Raise the right hand slowly, still keeping a light pressure on the clay with the thumb. The clay will rise with your hand. Now, insert the two first fingers of the left hand into the hollow and hold them against the wall. Slacken the speed of the wheel a bit. Bend the forefinger of the right hand and press the second joint and the knuckles against the outer wall to oppose the fingers which are inside. Press the thumbs together to steady the hands and raise both hands upward together. The fingers inside and outside the clay should be kept at a definite distance apart so that as the hands rise, the clay wall is brought to a uniform thickness. The thumbs must go straight down or the walls will flare out. Be sure to leave enough clay at the bottom to make a base.

Repeat the action of the fingers inside and out. Begin at the bottom and take a closer grip of the clay and draw up the walls as before. At all times, have your fingers directly opposite each other with a wall of clay between them, and your right thumb resting lightly on the top rim. Give the clay a chance to adjust itself as you move your fingers. The thinner you make the wall, the taller will be the cylinder. If you feel any place in the wall that is slightly thicker or thinner, exert more pressure for a thick place and less for a thin place.

Once you have started the movement from bottom to top, carry it through to completion. You can feel the roll of clay moving to the top. If you stop before reaching the top, you will leave a ridge of thickness where you stop. Even if you strive to keep the walls of the cylinder exactly the same thickness from top to bottom, the base and lower part of the wall will be slightly thicker. This is how it should be, since this part will be cut away on the outside in the turning or trimming process.

Never lose control of the top edge of the cylinder. The weight of your right thumb gently resting on the top edge is enough to keep it even. At no time exert too great a pressure any place except in the first centering. Let the wheel do most of the work. If you prefer a curved or tapered wall on the vase instead of a straight vertical wall, apply slight pressure where needed.

If you want the top of the wall to flare outward, for example, hold the fingers of your left hand against the inside surface, keeping the right hand directly opposite on the outside for support. For a concave curve, press the outside surface of the wall with the right hand, keeping the left inside for support. To widen the top so that the wall is straight but not vertical, hold your hand lightly against the entire length of the inside surface, at the same time supporting the outside. This is a delicate procedure and is not recommended for the beginner.

It is not possible to finish work to perfection by throwing. The clay is too soft to handle and for proper finishing the piece must be turned over to get at the bottom. For this, the clay must be leather-hard. As soon as the piece is thrown, wip off the excess moisture, remove the bat from the wheel head and allow the ware to stand until it can support itself. As the piece begins to dry, it will separate from the bat. Now place the leather-hard vase upon a clean bat. You are now ready to turn the vase.

Turning

If you have left sufficient clay at the base, you can turn a small foot - that is, hollow out the bottom slightly, leaving a rim around the outside for the vase to rest on. First, look inside the vase and study the curve in the bottom. This is the general contour you should try to cut on the outside of the base. Pick up the vase and lightly mark on the bottom so that you may cut enough from the outside to conform to the inside curve.

Turn the vase upside down on the new bat. Your first problem is to center the piece on the wheel. A pencil line may be drawn on the bat. Hold the pencil at the edge of the vase where it touches the bat and rotate the wheel slowly, holding the pencil in the position to make a circle slightly larger than the vase. Check to see if the piece is perfectly centered by doing this: take the pencil in your hand and steady your arm by holding it firmly against your side. Let the point of the pencil barely touch the vase. Turn the vase slowly. If the vase is centered properly, the pencil will touch it at all places as itrotates. If the piece is off-center, carefully move it until the pencil does touch at all points. Hold the vase in place by pressing at least three clay balls around the perimeter. These will keep the vase in place when the wheel is rotated. Otherwise, centrifugal force would send it flying off the bat.

Start the wheel spinning rapidly. With a cutting tool, starting at the center of the base and working out, cut out to the mark you made for the foot. Don't cut too deeply at first. It is better to go back and cut again. Use the tip of your tool and cut at right angles to the bottom of the vase. If the wheel is not turning fast enough, you will be plagued with ridges. Keep your wrists firm and hold the tool steady.

A small rim about one-quarter of an inch thick should be left for the base to stand on. Trim a contour on the lower outside which follows the inside curve.

An experienced thrower reduces the final work to a minimum. The more expert you become at throwing a piece the less cutting you will have to do when turning, except at the base. Do not expect to correct or remove throwing defects when you are turning. A piece must be thrown correctly if you want a worthwhile ware upon its completion.

After you are satisfied with the foot you have cut, clean the vase with a damp sponge while it is still spinning on the wheel. Apply the sponge to inside and outside surfaces to smooth off small pieces of clay and to dampen the wall slightly, which makes it easier to see how much additional cutting is necessary. Use a thin, flat, wet sponge, which you rest upon your fingers and work over the surface of the vase just as though the sponge weren't there. Never dab with the sponge. If more cutting is necessary, use the sponge again to remove the tool marks. Be sure you do not gouge or score too deeply.

If the piece requires a spout or a handle, these can be formed by the coil method and welded in place with mending slip. You may leave the marks that denote wheel work, or these may be fettled off with a damp sponge while rotating the wheel.