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Experiments in the Decorative Process of Salt-Glazing

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EXPERIMENTS IN THE DECORATIVE PROCESS OF SALT-GLAZING

A Thesis
Presented to
the Graduate Faculty
Central Washington State College

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

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by
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A special thanks to E. Frank Bach for his expert photography and time dedicated to achieve this high quality. And to my wife Bonnie, I express gratitude for her understanding and clerical assistance in completing this study.

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CHAPTER I

The use of salt as an agent to develop a ceramic glaze on clay can be traced to the twelfth century in Germany. It is not known who discovered salt-glazing or how this method of forming a glaze was developed. Salt may have been present in a clay body or saturated in wood used for kiln fuel. One idea tells the story of salt water accidently being dropped into a kiln resulting in a beautiful glaze which had formed on the raw clay.

Although the history of salt-glazing is spotty and uncertain, there is no uncertainty as to its value as a protective ceramic glaze, its rich texture, and its distinctive color effects.

Salt-formed glazes, the volatilization of common salt (sodium chloride) which brings about fusion of the body constituents on the surface of the clay, are one of the simplest and most natural ways to glaze clay objects. Salt-glazing techniques have been used industrially with great success because of its ease of application, sureness of coverage, resistance to organic and chemical attack and low economic factor. The artist potter has used salt-glazing as a meaningful medium for expression in his pursuit to create aesthetic and functional pottery.

I. THE PROBLEM

Statement of the Problem

It is the purpose of this study to explore the process of salt-glazing and to develop a representative range of colored salt-glazes by the application of soluble and insoluble metallic salts to the surface of the clay bodies.

Varying percentages of clay forming constituents and metallic salts were tested to determine their effects on the range and characteristics of the colors obtained, and the ability of the clay body to take a salt-glaze.

Firing techniques, kiln atmosphere control, and salting procedures were studied to determine their effects on the color of both clay and glaze, the ability of the clay body to take a glaze, and the development of orange-peel texture.

Importance of the Study

Based upon a review of literature, there is a void in both the amount and depth of research as well as publications dealing with all aspects of salt-glazing. The main body of technical information available is concerned with the industrial aspects of salt-glazed sewer pipes and decorative bricks. In the last decade there has been a revived interest in salt-glazing by the artist potters. During the months of January and February, 1969, an invitational exhibit of salt-glazed pottery was held at State University College in Genisco, New York.

The nature and technical development of salt-glazing present many suggestions as to color variations, textural qualities, and decorative procedures. These possibilities will expand the known means of glazing available to the candidate.

The historical development of salt-glazing, although sketchy, is an additional advantage to this study. It could be correlated with history units in the classroom or in the study of art history.

Limitations of the Study

It was intended in this study to use only a stoneware clay body for all salt-glazing tests. Two types of clay bodies were used, a fire clay-ball clay body, and a Jordan clay-ball clay body. The proportion of free silica, alumina, and alkalis were varied and a selection of metallic salts were added in various percentages to the clay bodies based upon a review of literature.

It was not intended in this study to attempt every possible percentage of metallic oxide, carbonate, nitrate, sulfate, and chlorite, or the combinations of these, but rather a representative sampling was studied which should indicate the scope of possibilities. Application of these metallic salts was limited to surface coverage on the biscuit ware.

There was not a limitation as to the number of pieces attempted, but rather a sampling was developed which should indicate the possibilities available both in complexity of shape and suitability of shape to the characteristics of salt-glazing.

Variations in salt-glaze texture were attempted in terms of the amount of salt used, length of time between saltings, variations in the kiln chamber atmosphere, and the percentage of soda ash and boric acid used to the percentage of sodium chloride.

The design and construction of the kiln are of secondary importance to the study. Experimental adjustments in the firing chamber will be attempted to improve firing and salting conditions, however only one kiln will be used and salting will be attempted at cone 5 (2156° F.) and cone 8 (2225° F.).

Definition of Terms

1. Salt-glazing: a vitreous coating formed on the surface of claywares by subjecting them to the action of an atmosphere of the fumes of common salt at a high temperature (2100° F. to 2300° F.) during the firing of the wares in the kiln.
2. Orange-peel texture: The surface appearance of salt-formed glaze which is pitted or resembles the accidental crawling of compounded glazes. May also be referred to as pig-skin or egg-shell texture.
3. Test rings: small rings of clay (about 2" in diameter) are placed in the kiln just beyond and in line with the peep-hole in the kiln door. At regular intervals in the firing and salting process, these clay rings are drawn from the kiln and checked for density, proper reduction, and the developed glaze thickness.
4. Down-draft kiln: the design of the kiln is such that the flame is deflected by bag walls up the sides of the kiln and then drawn down through the ware into a flue channel constructed in the bottom of the kiln below floor level.

5. Bag walls: the fire walls in a kiln which channel the course of the flame.
6. Draw-rod: a metal rod used to remove the test rings from the kiln.
7. Salting-scoop: a metal scoop with a long handle used to place and position the salt in the kiln.
8. Oxidation: a term used to describe an atmosphere inside the kiln chamber. An excess of air (oxygen) in the kiln.
9. Reduction: a term used to describe an atmosphere inside the kiln chamber. A deficiency of air (oxygen) for combustion. The abundance of fuel will seek oxygen from any oxide source including glazes and clays. The atmospheric circulation is lazy and some carbon can be seen as yellow or black smoke.
10. Shrinkage test: wet clay is formed into a rectangular shape, twelve inches by one inch, and fired to cone 9. The length was re-measured and the percentage of shrinkage was formulated.
11. Plasticity test: wet clay, about the diameter of a pencil is coiled around a small tube and checked for the formation of cracks or splitting.

CHAPTER II

REVIEW OF THE LITERATURE

Although the findings covering salt-glazing technology and techniques are extremely limited, it would seem that the writings reviewed are representative of those available. The majority of writings deals with the commercial application of technology and techniques; however, the use of this information for artistic endeavors seems logical. No reference has been located that suggests duplication of the present study in application of acquired technical knowledge or research procedures.

History of Salt-Glazing

Historically, salt-glazing has not enjoyed the intensity or depth of study found in other forms of pottery decoration. Ceramic remains, beginning with neolithic man and flourishing during Egyptian, Roman, and Oriental periods of civilization are commonly used by art historians and archaeologists as evidence of cultural, social, moral, and religious links in their studies. The significance of salt-glazed ware in ceramic history is often slighted or overlooked completely. There are conflicting statements as to the date or even century in which salt-glazing was developed. Glenn Nelson states that the oldest dated glaze and therefore our first knowledge of glazing, "...was found in Egypt on a green alkaline-glazed door tile in the tomb of King Menes about 3400 B.C." (20:156). The development of glazes in the European countries and in the Orient is recorded in many books, while the development of salt-glazing is only suggested with disagreement among authors as to the place of discovery and the method of discovery. Angelo Garzio (15:20) discusses the discovery of the secret of salt-glazing between the twelfth and thirteenth centuries by the potters of the Rhine river valley. J. F. Blacker expands this idea by adding, "...potters, notably those in the Rhineland, at Raeren, Frechen, Siegbury, Höhr, and Grenzhausen, began to apply salt-glaze to their products under the general name of Cologne ware..." (9:18). F. Carlton Ball (5:36) describes the development of clay bodies and salting techniques by the German potters as early as the sixteenth century. England was much later in its development of salt-glazing as reported by J. J. Young (28:359). She states that salt-glazing was discovered in England around the year 1680, and romantically writes:

> ...a servant of Mr. Joseph Yates, occupant of Stanley Farm, near Palmer's Pottery, Bagnall, was boiling salt water preparatory to using it in curing pork. An earthenware pot was used as a pan and the servant, having left it for a time, the water boiled over and would also appear to have boiled away, the pan became red hot. When it cooled, it was found to be covered with what was afterward called salt-glaze (28:359).

In the early years of the eighteenth century, salt-glazing became increasingly important to the potters in England. Under the leadership of John Dwight, a number of the Staffordshire potters turned their attention to the production of a light colored salt-glazed stoneware. Their interest in developing a ware comparable to Chinese porcelain lead them to the production of a white salt-glazes stoneware, called 'Crouch' ware (16:3), decorated with raised designs. G. Lewis

(18:93-96) reports the introduction of color in about 1740 with the dusting and rubbing of cobalt oxide on the raw clay. Potters at the Daulton Pottery, Vauxhall, developed grey colored clay bodies with broad bands of brown in their salt-glazed ware (16:166). The Martin Brothers, at Southall Pottery in Fulham, developed low tones of blues, greens, browns, blacks, and a crackle-finish in their salt-glazed ware (16:168). Salt-glazed stoneware by the Derbyshire potters ranged in color from yellow-buff to a dark brown and was commonly referred to as 'Chesterfield Ware' (16:146).

The increased interest and studies in other forms of glazing have limited the use of salt-glazing by the artist potter. However, this direction has not been obvious in the use of salt-glazing in industrial operations. One of the oldest potteries still producing salt-glazed ware today is Höhr-Grenzhausen, near Koblenz. Utilitarian ware such as: beer mugs, schnapps bottles, storage jars, jugs, and pitchers constitute the main product of this pottery and are in demand in the markets of Europe and the United States (15:20).

F. C. Ball (6:27) uses the date 1735 to establish the start of production of American-made salt-glazed pottery. These were simple utilitarian stoneware objects, such as crocks, jars, and jugs, with iron-brown or cobalt-blue painted designs or incised designs used for decoration. Ball (6:27) continues by listing such places as Albany, New York, Morgantown, West Virginia, and Bennington, Vermont as the major centers for the production of salt-glazed stoneware. This Early American stoneware shows the influence of the Rhine Valley potteries of

Germany in the use of both shape and colors, rather than the white salt-glazed ware of England. In the late 1800's, Bristol-glazed pottery was introduced to the United States and salt-glazing found its importance in industrial work. Ceramic engineers began to study salt-glazing and found it practical for industrial purposes. It was economical to use, offered resistance against chemical attack, and was sure in its coverage. Early in the twentieth century, studies were conducted to improve the composition of clay bodies used in salt-glazing (17:482-89). These studies lead to other investigations into color variations and control (3:70-79), low fire salt-glazing (10:82-83) and the use of borax and boric acid additions to improve glazing (26:36).

Although the ceramic engineers were concerned with industrial practices, the artist potter can find suggested techniques and factual data which, with slight modification, can be very useful for his purposes. Fosdick (13:219-220) reports of salt-glazing at cone 2 by a salt-bearing slip application which is directed toward the craftsman and individual potter. Modifications of industrial salt-glazing techniques are reported by Everhart (12:399-403) with primary interest in slip application and color variation. The design and construction of a small down-draft kiln for the purpose of salt-glazing was reviewed by H. G. Schurecht (25:45-46) with direct application of firing procedures and atmospheric conditions for the artist potter.

CHAPTER III

METHODS OF PROCEDURE

The procedure followed in this study was to design and construct an arched, 27 cubic foot, down-draft kiln for the purpose of salt-glazing. Test firings were conducted to establish firing characteristics and modifications of kiln chamber took place as needed.

Two stoneware clay bodies were used with variations of the silica, alumina, and alkaline content. Each body was tested for forming characteristics and its ability to take a salt-glaze. Various metallic salts were added to each clay body by weight percentages, and the body was tested for development of glaze, degree of orange-peel texture, the type of glaze finish, and color of clay body and developed glaze. Photographs and text describe each test conducted.

Soluble and insoluble metallic salts were applied to biscuit ware and salt-glazed at either cone 5 or cone 8. Photographs and text describe the resulting color.

The firing procedures used to achieve salt-glazing were varied and studied. The desired temperatures, type of kiln chamber atmosphere, and the rate of cooling are the major considerations and the results were recorded by photographs, text, and charts.

CHAPTER IV

EXPERIMENTS CONDUCTED IN SALT-GLAZING

Effects of the Clay Body Composition on Salt-Glazing

The ability of a clay body to take a salt-glaze depends in most part on the free silica-alumina ratio and the maturing temperature of the clay. L. E. Barringer (7:224-225) found that those clay bodies which take a good salt-glazing generally have compositions corresponding to 1 molecule of alumina to 4.6 to 12.5 molecules of silica. H. D. Foster (14:239) suggests a more liberal ratio of 1 molecule of alumina to 3.3 to 12.6 molecules of silica. With only a slight difference reported, the significance in glazing ability was found to be negligible. The clay bodies used in this investigation conformed to the limits of 1 molecule of alumina to 4.6 to 12.5 molecules of silica with only a slight difference evident in the glazing characteristics. The major difficulty in observing and reporting significant variations in the ability of a clay body to take a salt-glazing, is caused by the inability to reproduce exact firing and salting conditions from one test to another, or from one location to another in the chamber of the kiln.

A study by W. P. Rix (24:301) shows that silica alone could be salt-glazed, however, L. E. Barringer (8:154) disputes this idea by adding that silica alone could not be salt-glazed, and that a clay body was necessary. Barringer states, "...as a rule, all the constituents of the body are attacked by the salt fumes, and there results a soda-alumina-silicate with small proportions of the alkaline earths and iron included in the glaze (7:154). Beads of glaze were chipped from the surface of a sewer pipe, pulverized and chemically analyzed by L. E. Barringer to show the composition of a salt-glaze. The molecular formula is as follows:

Na_2O	1.326		
MgO	0.003		
K_2O	0.003		
CaO	0.297	Al_2O_3 1.00	SiO_2 4.418
FeO	0.078		

(7:158). This formula and investigations by Hursh and Clemens (17:482-489) confirm the necessity of a clay base, high in its free-silica content, for the sodium vapors to attack and the resulting glaze to form.

Two types of stoneware clay bodies were used in this investigation; the compositions for the first set of bodies are given in Table I.

TABLE I

VARIATIONS OF CONSTITUENTS IN A FIRE CLAY - BALL CLAY BODY

Clay Constituents	Clay Body Code Letters					
	A	B	C	D	E	F
Masons Blend Fire Clay	30	10	40	20	30	30
Kaiser Fire Clay	30	40	10	20	30	20
Kingman Feldspar	10	20	20	10	10	10
Kentucky Ball Clay	10	10	10	20	10	10
Flint	10	10	10	20	20	30
Sand	10	10	10	10	-	-

Fifty pound samples were made of each clay body and tested for shrinkage, plasticity, working characteristics, and ability to take a salt-glaze.

Body "A" represents the average composition as suggested by D. Rhodes (23:60), and was used as a standard of comparison for the other clay bodies.

Ten pound samples of each body in Table I were mixed, and various percentages of salts were added. Each specimen was formed into a shape and salt-glazed. The salts used, and their percentages are given in Table II.

TABLE II

VARIOUS PERCENTAGES OF METALLIC SALTS AND ALKALIS ADDED TO A FIRE CLAY - BALL CLAY BODY

Salt	Percent	Number Code
Red Iron Oxide	3%	1
Magnesium Carbonate	2%	2
Calcium Carbonate	2%	3
Albany Clay	4%	4
Manganese Dioxide	4%	5
Dolomite	4%	6
Dolomite	8%	7
Red Iron Oxide	6%	8

The decision to use the salts listed in Table II was based upon studies by R. K. Hursh and E. C. Clemens (17:482-489), H. G. Schurecht (25:45-46), and F. C. Ball (5:11). These salts were the only ones tested which caused any appreciable effect on either the color achieved, or the development of a glaze.

Body"A" represents the average composition; had a shrinkage at cone 9 of 11.5%, had good plasticity and workability on the wheel. Salt-glazed at cone 5 in a reduction atmosphere, the clay took a medium glaze of light grey to grey-brown color of good gloss and good orange-peel texture. Small black-brown spots of iron or carbon were distributed over the entire surface. Refer to page 20, plate 1.

Body "A-1," the addition of iron oxide had no effect on the physical properties of the clay body. Salt-glazed at cone 8 in a reduction atmosphere, the clay was brown-grey covered with a dark brown glaze of good gloss and pronounced but small orange-peel texture. Refer to page 21, plate 2.

Body "A-5," salt-glazed at cone 5 in a reduction atmosphere, was brown-grey covered with a dark brown to brown-black glaze of low gloss and extremely large orange-peel texture. Refer to page 20, plate 1.

Body"A-6," salt-glazed at cone 8 in a reduction atmosphere, was light grey with a light tan to green-yellow glaze of good gloss and orange-peel texture. Refer to page 20, plate 1.

Body "B," high in Kaiser Fire Clay, had a shrinkage of 13.0% at cone 9, had poor plasticity and was difficult to throw. Drying was difficult as the clay body was open and cracking was a major problem. Salt-glazed at cone 5 in a reduction atmosphere, the body was grey-brown with a dark brown glaze of medium gloss, and small orange-peel texture. Refer to page 22, plate 3.

Body "B-1," was salt-glazed at cone 5 in a partial reduction atmosphere, was grey-brown with a mahogany-brown glaze of medium gloss and small orange-peel texture. Refer to page 22, plate 3.

Body "C," highest in Masons Blend, had a shrinkage of 12.0% at cone 9 and was very plastic. This body lacked the required workability and cracking was a problem due to the fast drying characteristics of the body. Salt-glazed at cone 5 in an oxidation atmosphere, this body was light grey with a light yellow-brown glaze of medium gloss and small orange-peel texture. Refer to page 23, plate 4.

Body "C-6," salt-glazed at cone 8 in a reduction atmosphere, was light grey with a brown to brown-yellow glaze of medium gloss and good orange-peel texture. Refer to page 24, plate 5.

Body "D," highest in ball clay, and high in silica, had a shrinkage of 10.5% at cone 9, was very plastic, however, it was difficult to work in that it contained a small percentage of coarse materials. It tended to become very wet as work progressed. Salt-glazed at cone 5 in a reduction atmosphere, this body was light grey with a light grey-brown glaze of good gloss and small orange-peel texture. Small spots of iron were distributed evenly in the glaze. Refer to page 25, plate 6.

Body "D-5," salt-glazed at cone 5 in a reduction atmosphere, was dark grey, covered with a yellow-brown glaze of medium gloss and medium orange-peel texture. Refer to page 25, plate 6.

Body "D-6," salt-glazed at cone 5 in a reduction atmosphere, was light grey, with light brown to brown-yellow glaze of good gloss and medium orange-peel texture. Cobalt oxide was brushed over the clay, resulting in a vivid blue color. Refer to page 26, plate 7.

Body "E," similar to body "A," but higher in free-silica, had a shrinkage at cone 9 of 10.2%. The clay was very plastic and easy to work, with normal drying and firing characteristics. The clay body was salt-glazed at cone 8 in a reduction atmosphere and developed a light grey color, covered with a light grey-brown glaze of good gloss and good orange-peel texture. The increased addition of silica to the clay body had no effect on the developed glaze or in the colors achieved. Refer to page 27, plate 14.

Body "E-1," salt-glazed at cone 5 in a reduction atmosphere, was light grey-brown with a warm brown glaze of medium gloss and medium orange-peel texture. Refer to page 28, plate 8.

Body "E-2," salt-glazed at cone 5 in a reduction atmosphere, was light grey-brown, covered with a light brown glaze of low gloss, and good orange-peel texture. Some iron spots were found on the surface of the ware with some crystals formed at the edges. Refer to page 28, plate 8.

Body "E-3," salt-glazed at cone 5 in a reduction atmosphere, was light grey, covered with a brown to brown-green glaze of medium gloss, and medium orange-peel texture. The addition of calcium carbonate may have caused the darker color and the mat finish. Refer to page 29, plate 9.

Body "E-4," salt-glazed at cone 5 in a reduction atmosphere, was light grey, covered with a light green-brown to yellow-green glaze of good gloss, and good orange-peel texture. The addition of Albany clay had no effect on the physical properties of the body or on its firing characteristics. Refer to page 29, plate 9.

Body "E-7," salt-glazed at cone 5 in a reduction atmosphere, was light grey with a light-grey-brown glaze of good gloss, and good orange-peel texture. Refer to page 28, plate 8.

Body "E-8," salt-glazed at cone 5 in a reduction atmosphere, was dark brown, covered with a red-brown to purple-brown glaze of medium gloss, and poor orange-peel texture. The high percentage of iron oxide caused the glaze to be fluid, and the formation of crystals, on the surface of the clay. Refer to page 28, plate 8.

Body "F," had a shrinkage of 9.5% at cone 9, and was difficult to work, due to the high silica content. This body's plasticity was very bad, and poor drying characteristics accentuated cracking problems. Salt-glazing was done at cone 5 in a reduction atmosphere, with the body showing a grey color, and covered with a grey glaze of good gloss, and very poor orange-peel texture. Refer to page 30, plate 10.

Body "F-1," salt-glazed at cone 5 in a reduction atmosphere, was light grey-brown, covered with a light brown glaze with medium gloss, and orange-peel texture. Refer to page 31, plate 11.

The second stoneware body to be tested was derived from a study by F. C. Ball (5:17-35), in which sixteen different clays, including kaolins, ball clays, stoneware clays, fire clays, and red earthenware clays, were salt-glazed at cone 7 and cone 9. This investigation showed that Jordan clay took a good layer of glaze, had a good orange-peel texture, and was rich brown in color.

The compositions of Jordan clay-ball clay stoneware bodies used in this study are given in Table III.

TABLE III

VARIATIONS OF CONSTITUENTS IN A
JORDAN CLAY - BALL CLAY BODY

Clay Constituents	Clay Body Code Letters			
	G	H	I	J
Jordan clay	60	40	60	30
Kentucky ball clay	20	20	10	30
Flint	10	20	20	20
Kingman feldspar	10	10	10	10
Sand	-	10	-	10

Twenty-five pound samples of each body were made and tested to establish the ability of each body to take a salt-glaze and the color formed.

Body "G," salt-glazed at cone 8 in a reduction atmosphere, was medium grey, covered with a dark green to dark yellow-green glaze of good gloss, and excellent orange-peel texture. This body was exceptionally smooth to work, however, it became soft and deformed when fired at cone 8. Refer to page 32, plate 12.

Body "H," salt-glazed at cone 5 in a reduction atmosphere, was dark grey-blue, covered with a yellow to dark yellow-green glaze of good gloss, and good orange-peel texture. Refer to page 33, plate 15.

Body "I," salt-glazed at cone 5 in a reduction atmosphere, was dark grey, covered with a dark yellow-green to dark green glaze of good gloss, and good orange-peel texture. Refer to page 34, plate 16.

Body "J," salt-glazed at cone 5 in a reduction atmosphere, was medium grey, covered with a yellow-brown glaze. Four percent of dolomite was added to this body, causing a medium gloss and good orange-peel texture. Refer to page 35, plate 13.

PLATE 1

Left A, Middle A-5, Right A-6

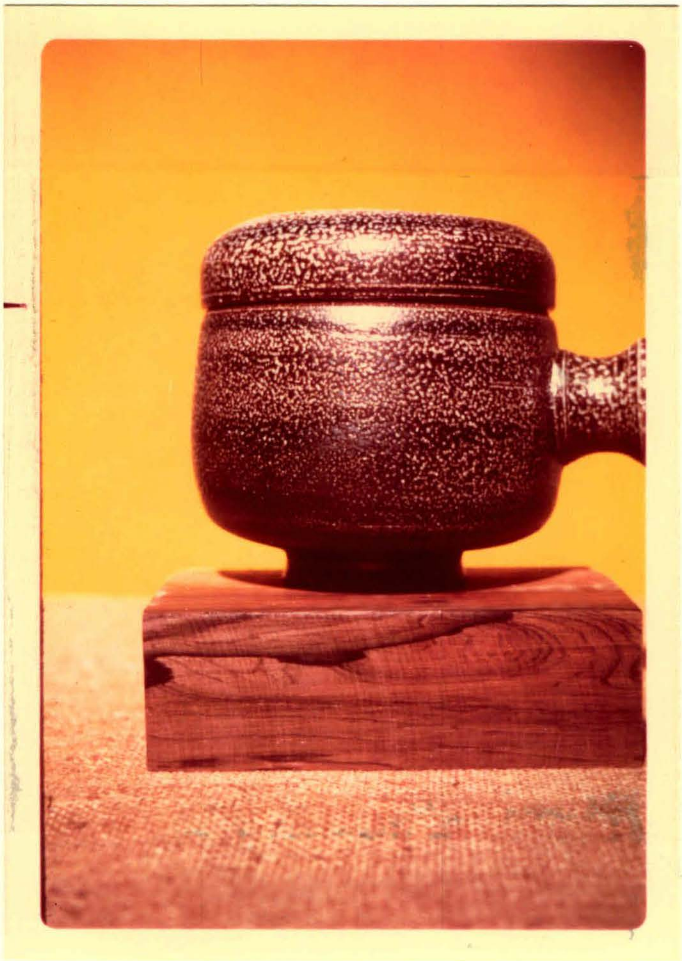

PLATE 2

A-1

PLATE 3

Left B, Right B-1

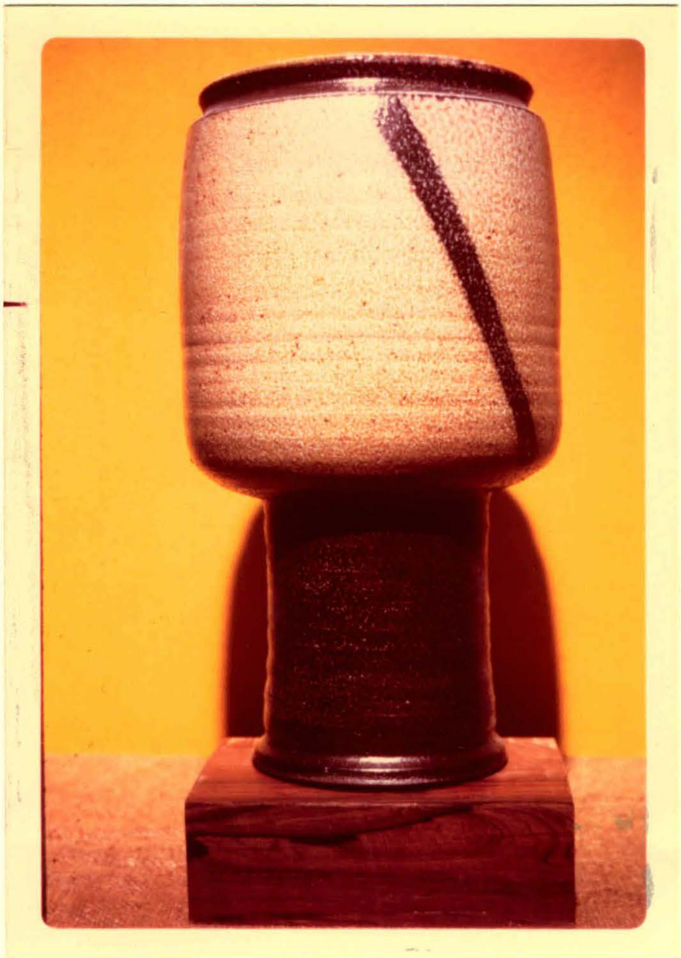

PLATE 4

C

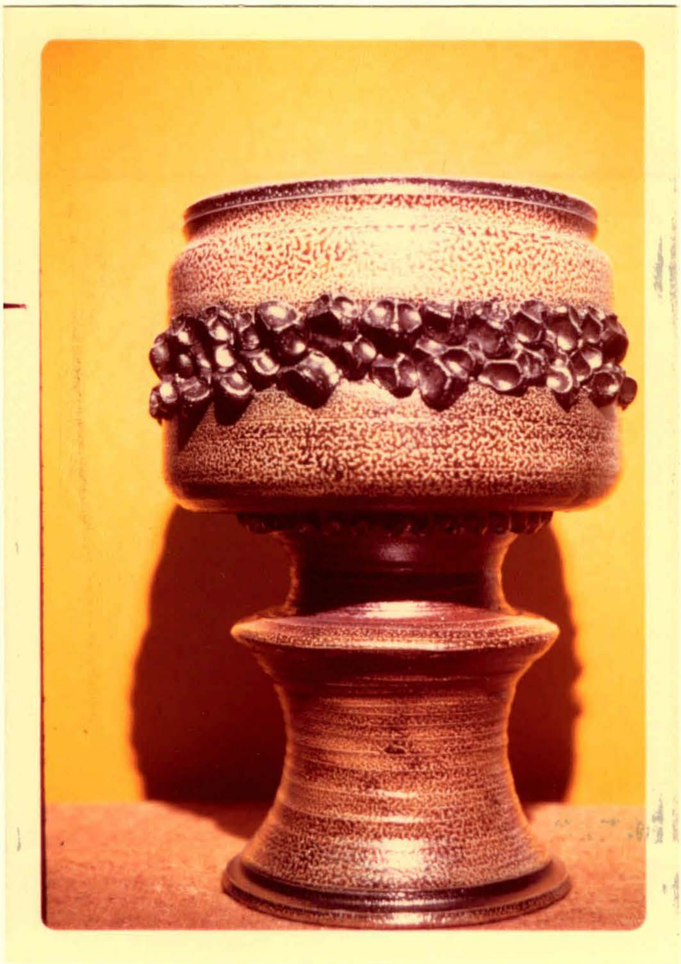

PLATE 5

C-6

PLATE 6

Left D, Right D-5

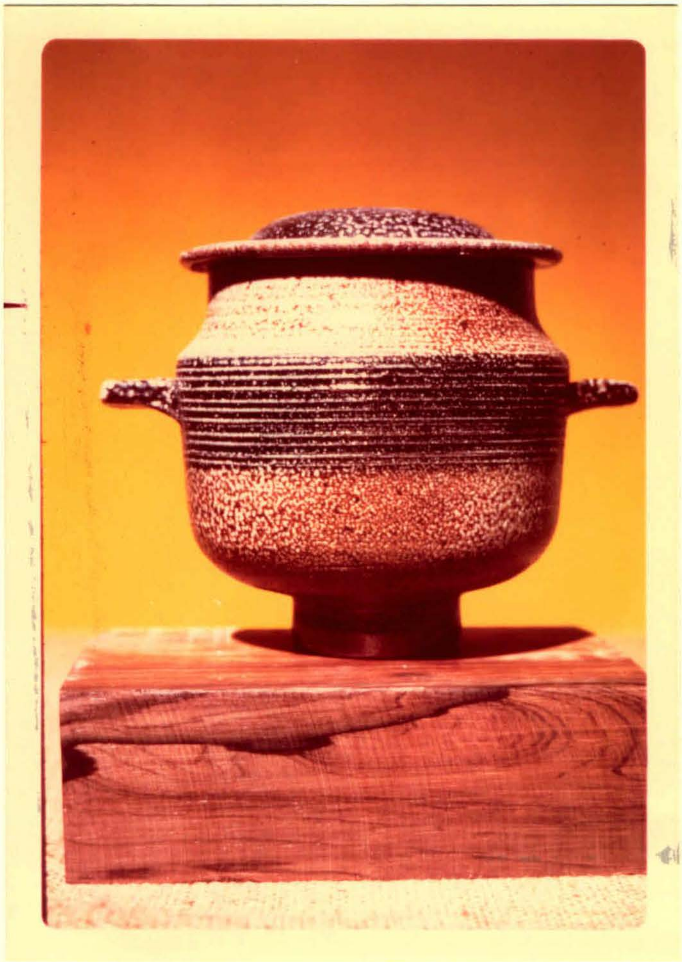

PLATE 7

D-6

PLATE 14

E

PLATE 8

Left E-1, Upper Middle E-2, Lower Middle E-7, Right E-8

PLATE 9

Left E-3, Middle E-4, Right E-5

PLATE 10

F

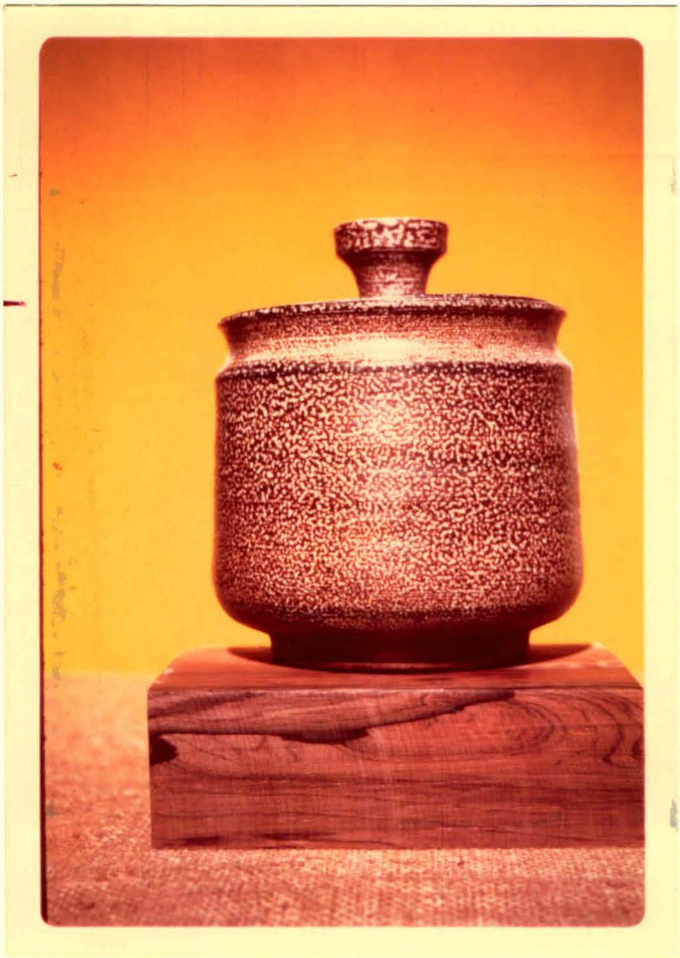

PLATE 11

F-1

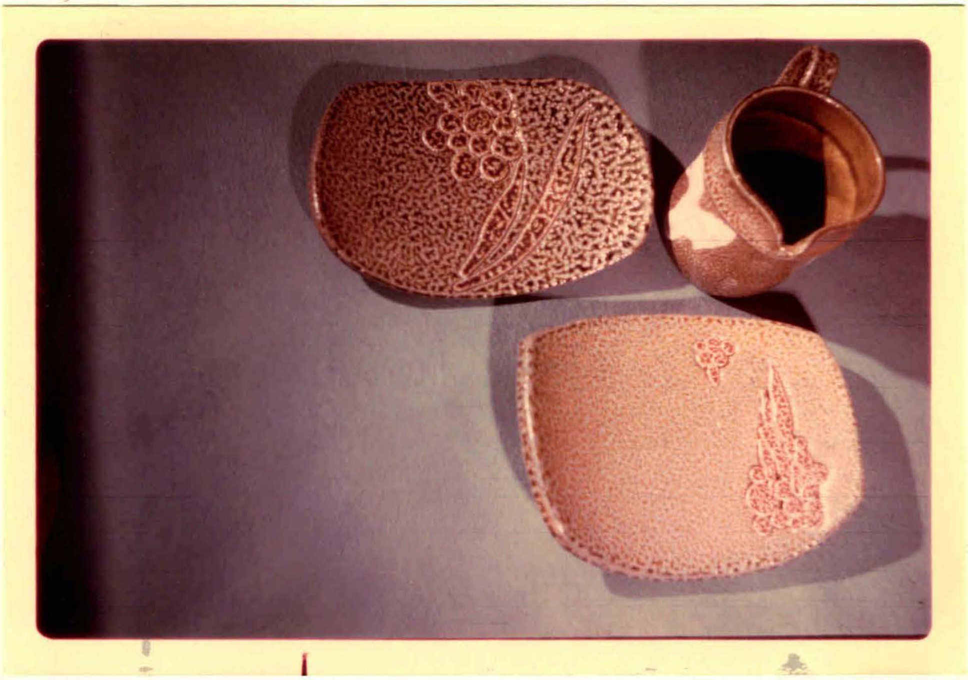

PLATE 12

G

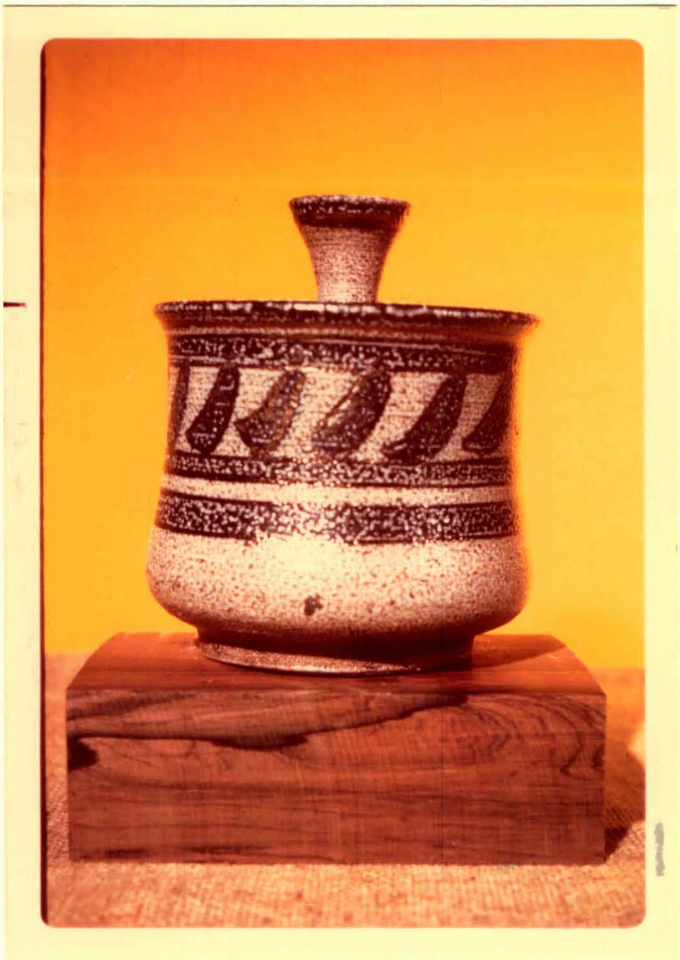

PLATE 15

H

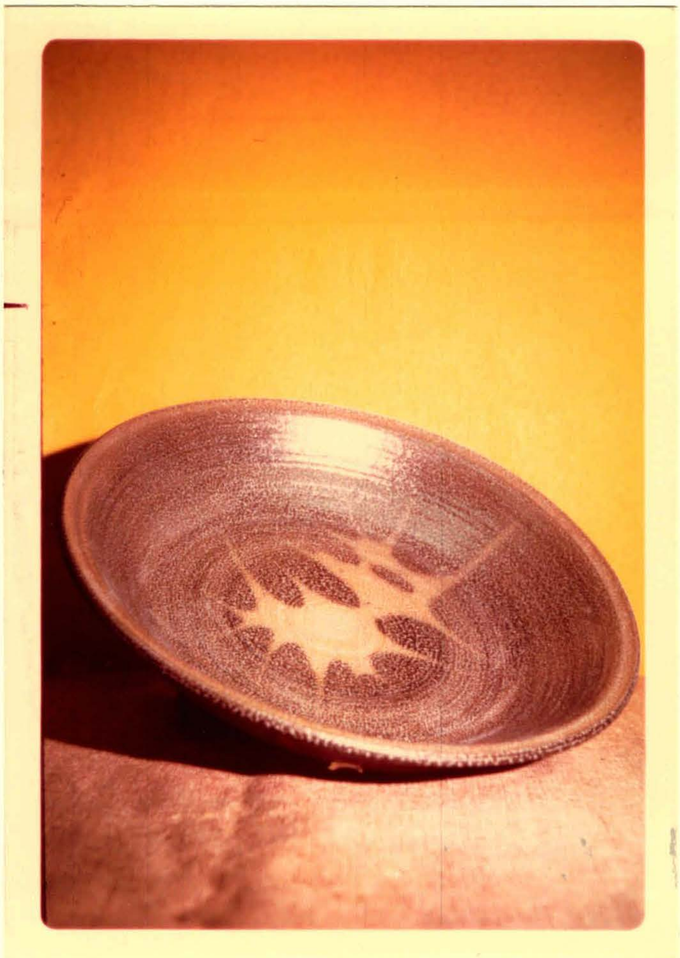

PLATE 16

I

PLATE 13

J

Effects of Metallic Salt on Salt-Glazing

The colors obtained from salt-glazing depend upon the character of the kiln atmosphere, the nature of the clay body constituents, and the application of insoluble and soluble metallic salts to the surface of the clay body. Theoretically, there is no mystery as to why a metallic salt, when combined with a glass, results in a certain color (23:127). The difficulty to reproduce exact color characteristics in salt-glazing is due to the inability to standardize the kiln atmosphere, and the lack of control in the amount of sodium gasses present in the chamber of the kiln.

The use of various metallic oxides added to slips, or in combination with water, can be traced to the German salt-glazed pottery. Cobalt oxide and manganese dioxide decorated much of the ware made at Grenhausen and Koblenz (6:27). Engobes containing volcanic lava, manganese dioxide, and cobalt oxide were used by potters in Höhr-Grenhausen to produce a pale yellow to a dark chocolate brown to a blue-brown ware (15:21-22). The English potters used metallic salts of cobalt, iron, and manganese to decorate their white or grey salt-glazed ware. Examples of fine detail work using various metallic salts are cited by L. W. Watkins (27:plates 86-107) in her discussion of the wares of the New England potters.

The application of a metallic salt which will combine with a formed glass to create various colors, may be accomplished by a variety of means. The use of clay slip containing metallic salts, applied to the surface of either greenware, or biscuitware, is described by

H. G. Schurect (25:46). These clay slips work well, however D. Rhodes (23:185) suggests a slip used in salt-glazing should contain considerable free-silica.

Metallic salts may also be combined with the sodium chloride, and introduced at the time of salting (24:46). The major problem with this technique is the accumulation of common salt and metallic salt in the chamber of the kiln, where subsequent firings would be affected by these deposits, causing difficulty in the control of desired coloring effects. It would also be difficult to control the percentage of metallic salt being used, as the amount of common salt-metallic salt solution used in one firing to another would vary depending upon the type of clay used, the temperature of the firing, and the kiln atmosphere.

Additions of metallic salts to a clay body are discussed by H. G. Schurecht (25:717) and R. K. Hursh and E. C. Clemens (17:482-489). The advantage in this procedure is the control of exact percentages of metallic salts to clay bodies. However, it would be a laborious task to develop a large variety of clay bodies to achieve variations of the desired colors. High percentages of some metallic salts will cause overfluxing of the clay bodies, resulting in softening of the ware. The problem of surface scumming is found when soluble metallic salts are used, which has a noticable poor effect on the salt-formed glaze.

In this study, the desired metallic salts, or combination of metallic salts were weighed on a triple-beam balance in their dry form. Water was also measured and added to the metallic salt in a porcelain mortar, ground to insure an even mixture, and to reduce the granular size of the salts. These mixtures were applyed to the biscuit ware with a brush. The advantages in using this method are: Ease of application, a reduction in the risk of blisters and pinholes in the formed glaze, a wide variety of metallic salts could be used, and small amounts of metallic salts were required, which reduced the investment cost. All of the clay bodies used in this study were of body "A" (refer to Table I), with the addition of 4% dolomite. The results of the various metallic salts used are:

Iron Oxide, 100%. Twenty-five grams of Fe_2O_3 were mixed with 100 ml. of water and applied to the biscuit ware. Salting was accomplished at cone 5 in a reduction atmosphere, causing the iron to change from a ferric state to a ferrous state, resulting in a dark brown to brown-black color. Refer to page 49, plate 17.

Iron Oxide, 100%. Ten grams of Fe_2O_3 were mixed with 100 ml. of water and applied to the biscuit ware. Salting was accomplished at cone 8 in a reduction atmosphere. The resulting color was dark brown to brown-black, and uneven in distribution. Refer to page 50, plate 18-1.

Iron Oxide, 80%, Manganese Dioxide, 20%. Twenty-five grams of Fe_2O_3 and MnO_2 were mixed with 100 ml. of water and applied to the biscuit ware. Salting was accomplished at cone 8 in an oxidation atmosphere. The glaze color was light yellow-brown to warm brown. Refer to page 50, plate 18-2

Iron Oxide, 60%, Manganese Dioxide, 40%. Ten grams of Fe_2O_3

and MnO_2 were mixed with 40 ml. of water and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was black-brown with some crystal formations found. Refer to page 53, plate 23-2.

Iron Oxide, 80%, Whiting, 20%. Ten grams of Fe_2O_3 and $CaCO_3$ were mixed with 40 ml. of water and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was warm brown to yellow-brown. Refer to page 51, plate 20-3.

Iron Oxide, 70%, Whiting, 30%. Ten grams of Fe_2O_3 and $CaCO_3$ were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was black-brown to warm brown. Refer to page 58, plate 28-1.

Iron Oxide, 50%, Whiting, 50%. Ten grams of Fe_2O_3 and $CaCO_3$ were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was warm brown to medium yellow-brown. Refer to page 58, plate 28-2.

Iron Oxide, 90%, Rutile, 10%. Twenty-five grams of Fe_2O_3 and rutile were mixed with 100 ml. of water, applied to the biscuit ware, and salt-glazed at cone 8 in a reduction atmosphere. The resulting color was dark brown with small orange-peel texture. Refer to page 61, plate 39.

Iron Oxide, 80%, Rutile, 20%. Ten grams of Fe_2O_3 and rutile were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 8 in a reduction atmosphere. The resulting color was dark brown with medium orange-peel texture. Refer to page 59, plate 29.

Iron Oxide, 60%, Rutile, 40%. Twenty-five grams of Fe_2O_3 and rutile were mixed with 100 ml. of water, applied to the biscuit ware and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was yellow-brown to golden brown, with almost no orange-peel texture. Refer to page 60, plate 30.

Iron Oxide, 70%, Barnard clay, 30%. Twenty-five grams of Fe_2O_3 and Barnard clay were mixed with 100 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dark brown to dark yellow-brown. Refer to page 62, plate 46.

Iron Oxide, 50%, Barnard clay, 50%. Ten grams of Fe_2O_3 and Barnard clay were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was black-brown with no orange-peel texture. Refer to page 57, plate 27-4.

Ferrous Chloride. A $FeCl_2$ solution was applied to the biscuit ware and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was light yellow-brown to medium brown. Refer to page 52, plate 21-3.

Iron Chromate, 100%. Ten grams of $FeCrO_4$ were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was black-brown with small orange-peel texture, which enabled detail work with sharp edges. Refer to page 54, plate 24-3.

Crocus Martis, 100%. Ten grams of crocus martis were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dark chocolate brown to black-brown. Refer to page 54, plate 24-4.

Cobalt Oxide, 100%. Fifteen grams of CoO were mixed with 100 ml. of water, applied to the biscuit ware, and salt-glazed at cone 8 in a reduction atmosphere. The resulting color was bright blue with a small orange-peel texture. Refer to page 63, plate 47.

Cobalt Oxide, 10% Copper Carbonate, 90%. Ten grams of CoO and $CuCO_3$ were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was pale blue, bordered by flashes of pink. Refer to page 58, plate 28-4.

Cobalt Oxide, 20%, Copper Carbonate, 80%. Ten grams of CoO and $CuCO_3$ were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was bright blue to dark blue-green with good orange-peel texture. Refer to page 53, plate 23-3.

Cobalt Oxide, 40%, Copper Carbonate, 60%. Ten grams of CoO and $CuCO_3$ were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dark blue to dark blue-green. Refer to page 53, plate 23-4.

Cobalt Oxide, 50%, Copper Carbonate, 50%. Ten grams of CoO and $CuCO_3$ were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 8 and in a reduction atmosphere. The resulting color was bright blue, to bright dark blue. Refer to page 64, plate 31.

Cobalt Oxide, 70%, Iron Oxide, 30%. Twenty grams of CoO and Fe_2O_3 were mixed with 100 ml. of wax resist emulsion (Ceremul A,) applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was medium blue to blue-brown. Refer to page 65, plate 19.

Cobalt Oxide, 10%, Copper Carbonate, 40%, Iron Oxide, 50%. Ten grams of CoO, $CuCO_3$, and Fe_2O_3 were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dark blue-green to black-blue. Refer to page 54, plate 24-1.

Cobalt Oxide, 20%, Copper Carbonate, 50%, Iron Oxide, 30%. Ten grams of CoO, $CuCO_3$, and Fe_2O_3 were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was grey-brown with a trace of blue, to blue-green. Refer to page 54, plate 24-2.

Cobalt Chloride, 100%. A 5% solution, applied to the biscuit ware, was salt-glazed at cone 5 in a reduction atmosphere. The resulting color was pale blue to pale blue-green. Refer to page 52, plate 21-2.

Cobalt Oxide, 80%, Iron Oxide, 20%. Twenty-five grams of CoO and Fe_2O_3 were mixed with 100 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dark blue to dark blue-black. Some dark brown spots were present in the glaze. Refer to page 66, plate 32.

Cobalt Oxide, 30%, Copper Carbonate, 40%, Rutile, 30%. Twenty-five grams of CoO, $CuCO_3$ and rutile were mixed with 100 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was medium to light blue, blue-green, to yellow-green. Refer to page 67, plate 33-1.

Cobalt Oxide, 70%, Copper Carbonate, 20%, Rutile, 10%. Twenty-five grams of CoO, $CuCO_3$, and rutile were mixed with 75 ml. of liquid wax, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was bright blue, to bright blue-green, with some evidence of pink at the edges of the color bands. Refer to page 68, plate 48-1.

Cobalt Oxide, 10%, Copper Carbonate, 30%, Iron Oxide, 30%, Rutile, 30%. Twenty-five grams of CoO, $CuCO_3$, Fe_2O_3, and rutile were mixed with 100 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was a mat, dark blue to dark blue-green, to brown-green. Refer to page 69, plate 49-1.

Manganese Dioxide, 100%. Ten grams of MnO_2 were mixed with 40 ml. of water, applied to the biscuit ware, salt-glazed at cone 8 in a reduction atmosphere. The resulting color was dark chocolate brown, to dark yellow-brown. Refer to page 53, plate 23-1.

Manganese Dioxide, 60%, Cobalt Oxide, 20%, Rutile, 20%. Twenty-five grams of MnO_2, CoO, and rutile were mixed with 100 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dark, muddy green, to muddy brown, with some evidence of blue. Refer to page 70, plate 50.

Uranium Oxide-Yellow, 100%. Ten grams of $Na_2U_2O_7 \cdot H_2O$ were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was bright yellow with some dark brown spots. Refer to page 51, plate 20-1.

Uranium Oxide-Yellow, 60%, Iron Oxide, 40%. Ten grams of $Na_2U_2O_7 \cdot H_2O$ and Fe_2O_3 were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dark brown over a yellow, to yellow-brown. It did not appear as though the uranium oxide-yellow and iron oxide combined, but rather the iron came to the surface, blocking the effects of the uranium. Refer to page 51, plate 20-2.

Uranium Oxide-Yellow, 80%, Iron Oxide, 20%. Ten grams of $Na_2U_2O_7 \cdot H_2O$ and Fe_2O_3 were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was medium yellow-brown to mustard brown. Refer to page 55, plate 25-5.

Uranium Oxide-Yellow, 60%, Iron Chromate, 40%. Ten grams of $Na_2U_2O_7 \cdot H_2O$ and $FeCrO_4$ were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dark olive green, to muddy green. Refer to page 56, plate 26-1.

Uranium Oxide-Yellow, 80%, Nickel Oxide, 20%. Ten grams of $Na_2U_2O_7 \cdot H_2O$ and NiO were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dark grey-brown with traces of yellow-brown. Refer to page 55, plate 25-1.

Nickel Oxide, 100%. Ten grams of NiO were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was black-brown to black. refer to page 55, plate 25-3.

Nickel Chloride, 100%. Five grams of $NiCl_2$ were mixed with 20 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was a dark brown-grey to black, with a very broken texture. Refer to page 52, plate 21-1.

Nickel Oxide, 60%, Iron Oxide, 40%. Twenty-five grams of NiO and Fe_2O_3 were mixed with 100 ml. of water, applied to the biscuit ware, salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dark brown to black-brown with some traces of dark green. Refer to page 71, plate 51.

Nickel Oxide, 80%, Rutile, 20%. Twenty-five grams of NiO and rutile were mixed with 100 ml. of water, applied to the biscuit ware and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was medium green-brown to dark green-brown. Refer to page 69, plate 49.

Cobalt Sulfate, 50%, Nickel Chloride, 50%. Twenty-five ml. were mixed, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was muddy brown to grey-brown. Refer to page 56, plate 26-3.

Cobalt Sulfate, 25%, Nickel Chloride, 75%. Twenty-five ml.

were mixed, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was grey-black to black-brown. Refer to page 56, plate 26-5.

Cobalt Sulfate, 75%, Nickel Chloride, 25%. Twenty-five ml. were mixed, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was grey-brown to muddy brown. Refer to page 56, plate 26-4.

Albany Clay, 100%. Twenty-five grams of Albany clay were mixed with 75 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was warm yellow-brown to rich orange-brown. Refer to page 57, plate 27-3.

Albany Clay, 80%, Manganese Dioxide, 20%. Ten grams of Albany clay and MnO_2 were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was rich brown to dark brown-black. Refer to page 72, plate 52-2.

Albany Clay, 80%, Iron Oxide, 20%. Ten grams of Albany clay and Fe_2O_3 were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was medium brown to yellow-brown. Refer to page 73, plate 34-2.

Albany Clay, 80%, Barnard Clay, 20%. Ten grams of Albany clay and Barnard clay were mixed with 40 ml. of water, applied to the biscuit ware and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was medium brown to light yellow-brown. Refer to page 67, plate 33-2.

Molybdenum Trioxide, 100%. Ten grams of molybdenum trioxide were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was blue-black, brown-black, to red-brown-black. Refer to page 58, plate 28-5.

Amblygonite, 100%. Ten grams of amblygonite were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was brown-orange with dark brown at the edges. Refer to page 74, plate 35.

Amblygonite, 100%. Twenty grams of amblygonite were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was bright orange to dark orange-brown. Refer to page 75, plate 36.

Amblygonite, 80%, Iron Oxide, 20%. Ten grams of amblygonite and Fe_2O_3 were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dull orange to orange-brown. Refer to page 76, plate 37.

Amblygonite, 60%, Rutile, 40%. Ten grams of amblygonite and rutile were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was dull orange to light rust brown. Refer to page 77, plate 38.

Chrominum Nitrate, 100%. Ten grams of chromium nitrate were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting color was rich mahogany brown. Refer to page 73, plate 34-1.

Zircopax, 100%. Ten grams of Zircopax were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting effect was the development of a creamy white glaze of good gloss, and no orange-peel texture. Refer to page 78, plate 53.

Zirconium Spinel, 100%. Ten grams of zirconium spinel were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting effect was the development of a golden brown to light brown glaze of good gloss and no orange-peel texture. No example shown.

Barium Carbonate, 100%. Ten grams of barium carbonate were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting effect was the development of a translucent white glaze of medium gloss and no orange-peel texture. The glaze was highly crazed. No example shown.

Raw Kaolin, 100%. Ten grams of raw kaolin were mixed with 40 ml. of water, applied to the biscuit ware, and salt-glazed at cone 5 in a reduction atmosphere. The resulting effect was the development of a light brown glaze of good gloss and orange-peel texture. No example shown.

PLATE 17

PLATE 18

Left 1, Right 2

PLATE 20

Left 1, Upper middle 2, Lower middle 3, Right 4

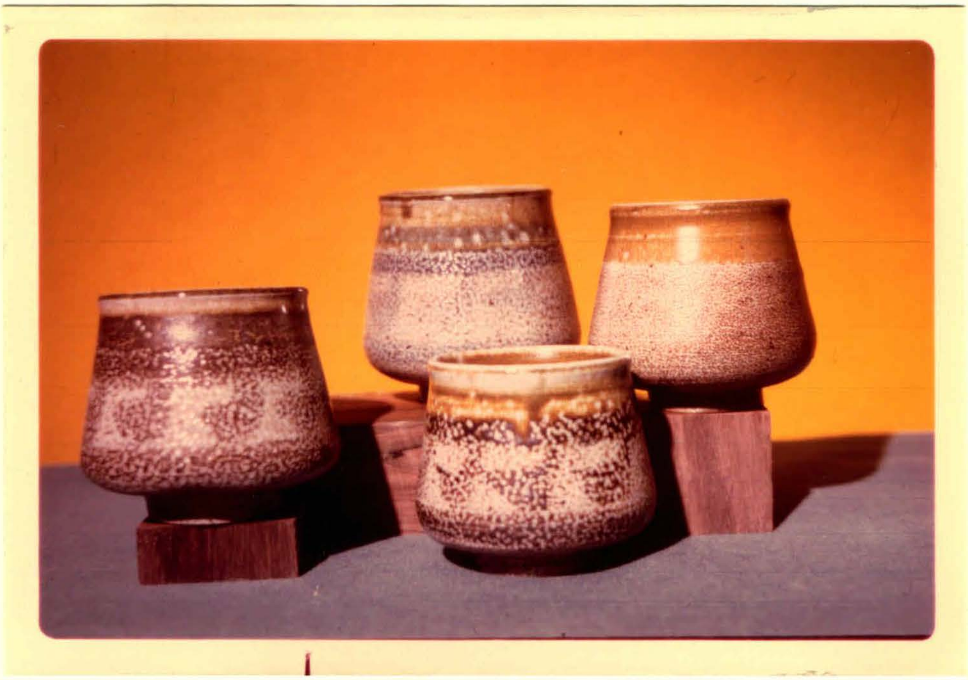

PLATE 21

Left 1, Upper middle 2, Lower middle 3, Right 4

PLATE 23

Left 1, Upper middle 2, Lower middle 3, Right 4

PLATE 24

Left 1, Upper middle 2, Lower middle 3, Right 4

PLATE 25

Lower left 1, Upper left 2, Lower middle 3
Lower middle 4, Right 5

PLATE 26

Lower left 1, Upper left 2, Lower middle 3
Right 4, Upper right 5

PLATE 27

Lower left 1, Upper left 2, Upper middle 3
Lower middle 4, Right 5

PLATE 28

Lower left 1, Upper left 2, Upper middle 3
Lower middle 4, Right 5

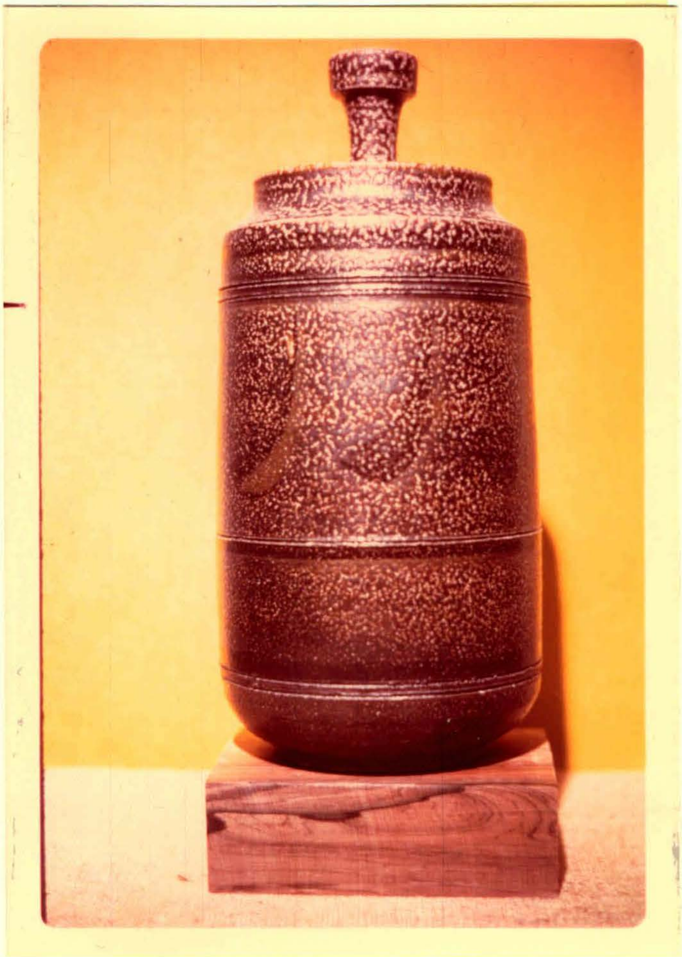

PLATE 29

PLATE 30

PLATE 39

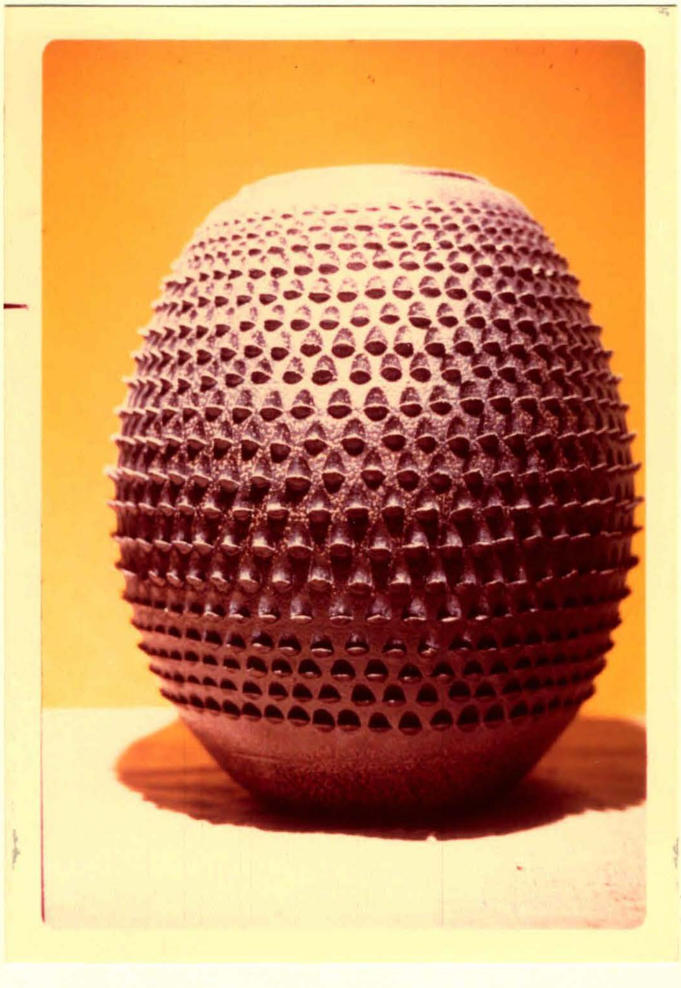

PLATE 46

PLATE 47

PLATE 31

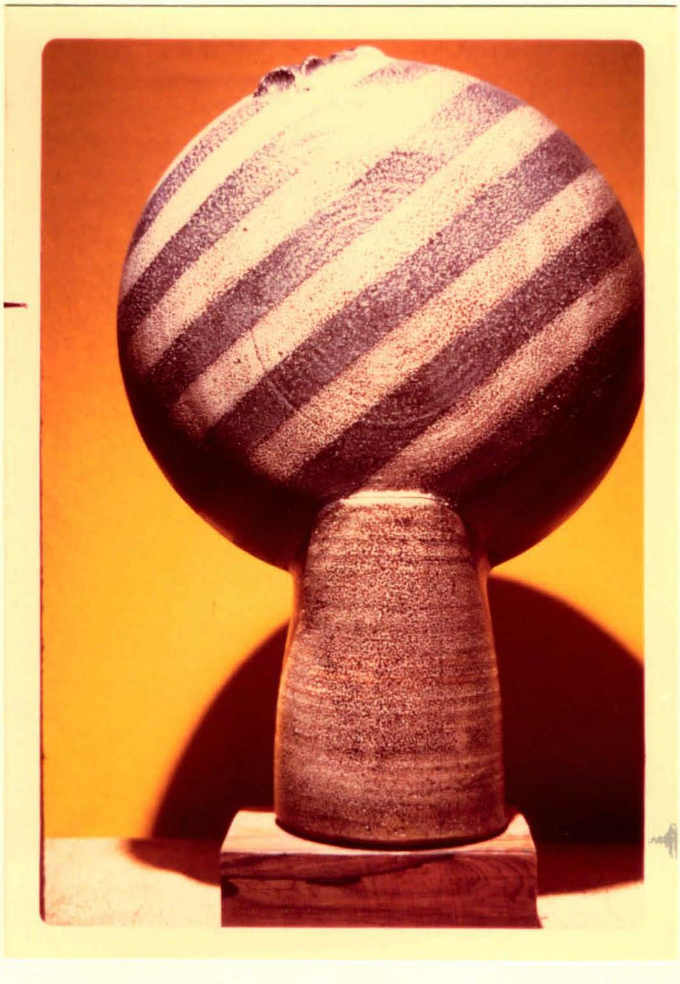

PLATE 19

PLATE 32

PLATE 33

Left 1, Right 2

PLATE 48

Left 1, Right 2

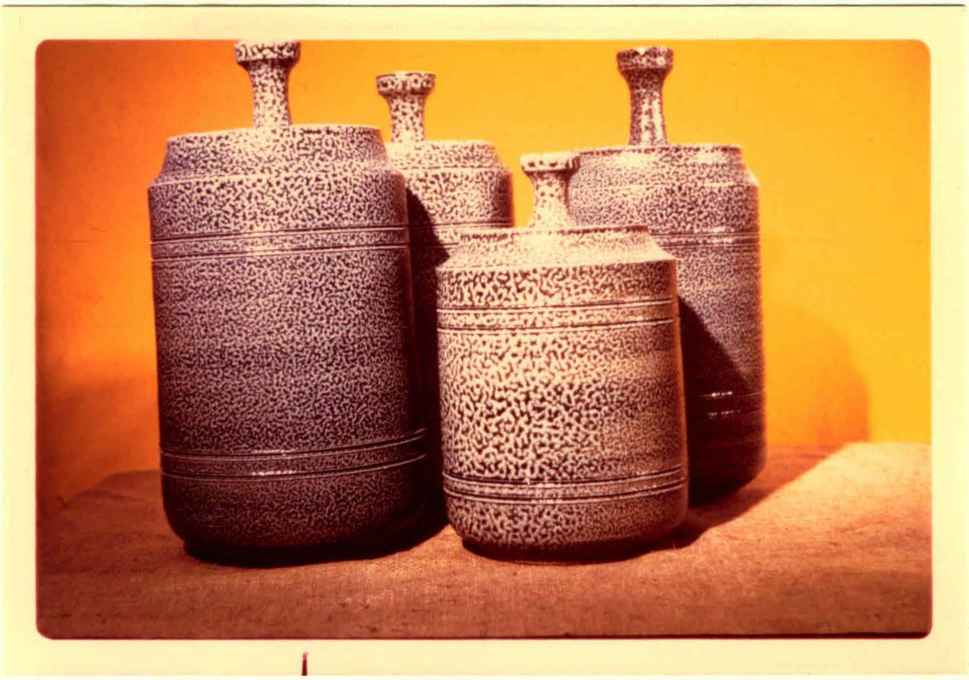

PLATE 49

PLATE 50

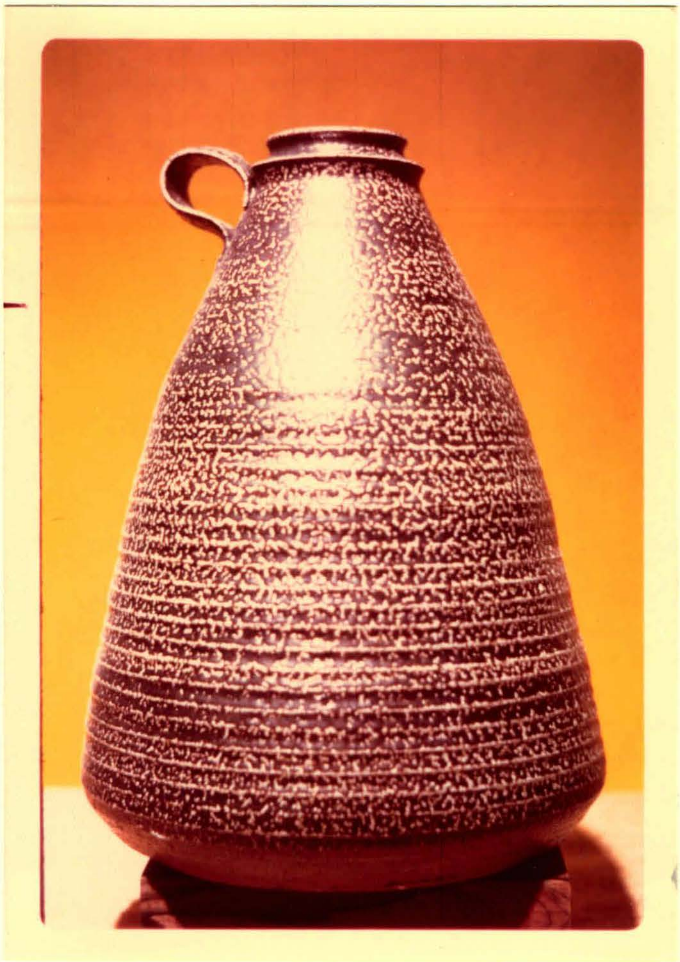

PLATE 51

PLATE 52

Left 1, Right 2

PLATE 34

Left 1, Right 2

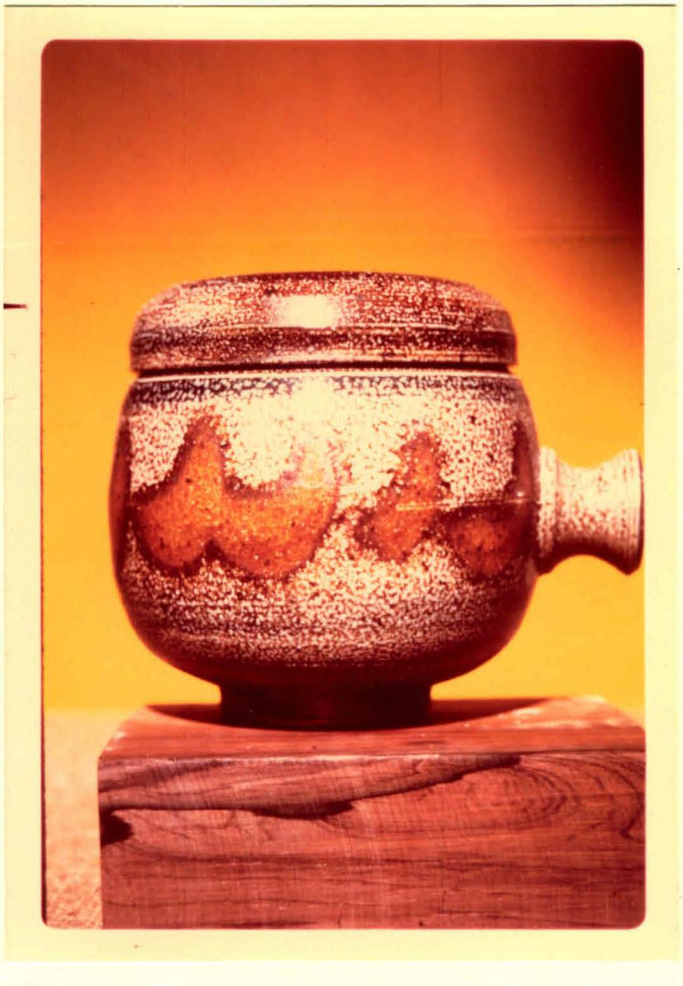

PLATE 35

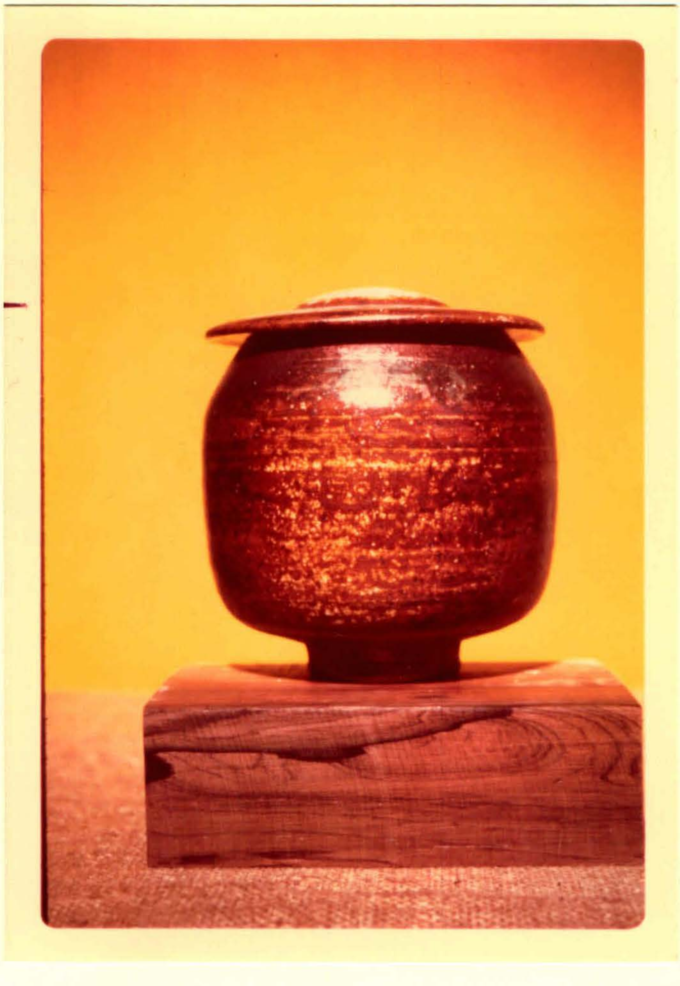

PLATE 36

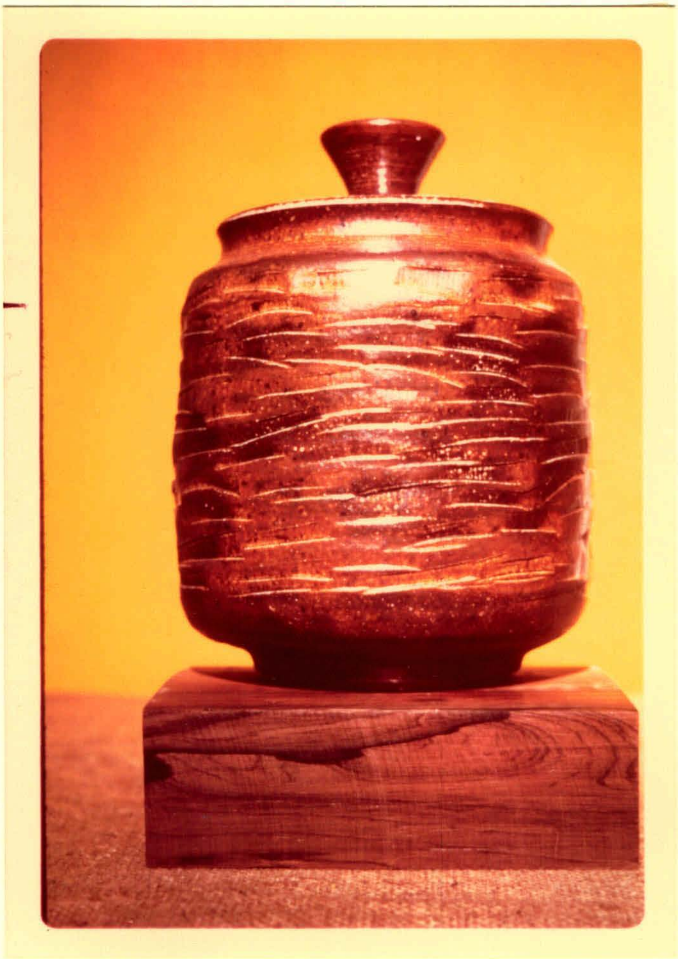

PLATE 37

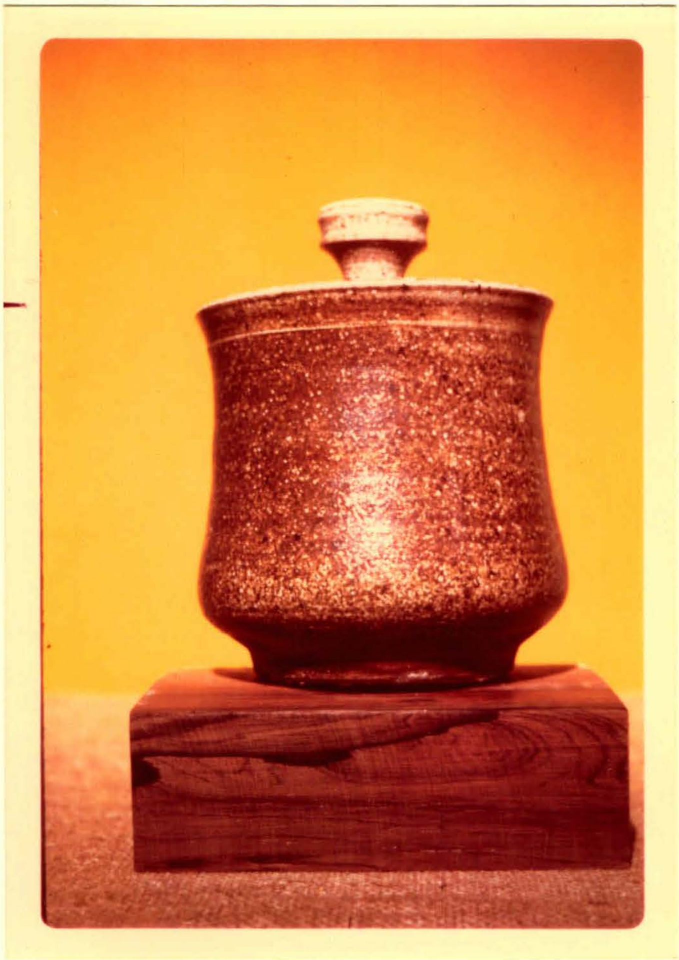

PLATE 38

PLATE 53

Effects of the Kiln Atmosphere in Salt-Glaze Firing

The type of kiln atmosphere, either oxidation or reduction, affects the colors of clay bodies, colors of salt-glazes, the character of the glaze texture, and the efficiency of the salting procedures.

D. Rhodes (23:171-182) discusses the effects of reduction conditions on clay bodies, and the color range of reduction fired glazes. F. H. Norton (21:193) states the conditions required for a reduction atmosphere and the effects it has on the clay bodies and glazes. Although these authors do not address themselves to the problems of reduction atmospheres in salt-glazing, their theories and technical information can be directly applied.

Discussions of whether an oxidation or a reduction atmosphere is better for the formation of salt-glaze are as varied as they are widespread. Anon (2:228-229) cites a number of German potters, each professing a different philosophy regarding more desirable atmospheric conditions for salt-glazing. Some maintain that oxidation conditions must be held throughout the firing for the best salting results; others state that oxidation conditions are held until the salting procedures begin, and then reduction conditions should prevail. W. R. Rix (24:301) concludes that once the surface of the clay body has been vitrified, no further change in conditions will have any effect. C. R. Austin and J. O. Everhart (3:79) state that an oxidation atmosphere is essential to the production of salt-glazed ware.

In this study, three oxidation firings were conducted. No standard method of controlling the excess amount of air was used.

The primary air controls were moved to an open position during the entire firing and salting process. The draft damper was placed at a position of six inches or more. (Refer to Appendix "A") These procedures and the lack of any visual reduction atmospheric conditions, made it safe to assume that an oxidation atmosphere was obtained. The results of these conditions were noticed in the light brown to buff color of the clay bodies and the transparent qualities of the salt-glazes. These glazes were extremely glossy and with small-orange peel texture. The major difficulty, when the kiln is in an oxidation condition, is that a great amount of salt is required to create the desirable glaze thickness. Once the sodium chloride has been changed from a solid to a vapor by the heat of the kiln, the adjustments necessary for firing with an oxidation atmosphere did not allow these vapors to remain in the firing chamber long enough for efficient glaze forming action. When salting occured, there was a decrease in the temperature of the firing chamber due to the lower temperature of the salt. This was overcome by allowing the kiln to fire undisturbed for a period of ten to twenty minutes between saltings to bring the heat up again. The number of saltings required and the length of time between saltings under oxidation conditions make this procedure cumbersome to use.

Hursh and Clemens (17:488) state that reduction atmospheres aid greatly in almost every aspect of salt-glazing. Anon (2:229) discusses the differences between salt-glazing in an oxidation atmosphere and in a reduction atmosphere, concluding that no significant difference was observed. W. P. Rix (24:301) states that if salt is introduced into a reduction atmosphere, the ware is always dark and blackish, a condition which cannot be remedied afterwards.

The effects of a reduction atmosphere on the color of the salt-glazed ware were studied by Fosdick (13:219-220), Everhart (12:399-403), Dingledine (10:82-83), Hursh and Clemens (17:488), and Schurecht (25:45-46). The major conclusion drawn was that the resulting colors were darker and usually better developed than those created in an oxidation atmosphere. This darker color was due to either the surface reduction of the clay body or the deposit of carbon in the glaze.

In this study, 24 salt-glaze firings were conducted in a reduction atmosphere. The clay bodies used (body "A," refer to Table I) were reduced from cone 010 (1634° F.) onward by decreasing the primary air supply and adjusting the damper to a position of two (refer to Appendix A.) When the desired temperature for introducing the salt into the kiln was achieved, a heavy reduction was achieved by increasing the gas volume to full, and a total elimination of the primary air supply. Heavy black smoke was evident coming from cracks in the firing box, and yellow flame rising three to four feet could be seen inside the stack. These visual signs suggested the conditions usually accompanying a reduction atmosphere. The clay bodies were grey to grey-black in color at both cone 5 (2156° F.) and cone 8 (2230° F.). The glaze colors were more subtle and lower in intensity than those formed in an oxidation atmosphere.

Using a reduction atmosphere, the amount of salt required to achieve the desired glaze thickness was greatly reduced, compared to the amount necessary when an oxidation atmosphere was used and the same glaze thickness attempted. Because the reduction flames move lazily through the kiln, heat and salting vapors were more evenly distributed throughout the firing chamber, which proved to be desirable to the development of the glaze and glaze color.

Effects of the Additions of Salts of Soda and Related Alkalis

The use of common salt (sodium chloride) is the most popular and economical source of sodium for salt-glazing. However, studies were conducted to find a substitution for sodium chloride which might cause as good a glaze and which would reduce or eliminate the toxic by-product of hydrochloric fumes. Everhart (12:399-403) reports the use of sodium carbonate as a substitute for sodium chloride.

In this study, combinations of 50% sodium chloride to 50% sodium carbonate, and 70% sodium chloride to 30% sodium carbonate were used with good results. The amounts required to create a suitable glaze thickness were one and one-half to three times greater than with the use of sodium chloride alone, due in part to the small granular size of the sodium carbonate. A mixture of 70% sodium chloride and 30% sodium carbonate was used at cone 5 in a reduction atmosphere, resulting in little change in the color of the clay body, or the resultant salt-glaze. These glazes had a good orange-peel texture and were with the same general characteristics of glaze hardness and glaze coverage found in 100% sodium chloride formed glazes. Refer to page 88, plate 41.

Studies using additions of borax and boric acid to the sodium chloride were reported by Foster (14:241), Anon (1:242), Schurecht

(25:45-46), and Schurecht and Wood (26:36-38). The experimental work carried out by these investigators proved that the use of borax or boric acid in combination with sodium chloride improves the appearance of the developed glaze color and glaze gloss. These glazes were smoother and thicker, and had less crazing than glazes produced without the additions of borax or boric acid, due to a lower coefficient of expansion than sodium chloride. The major difference found in the use of boric acid and borax was that more boric acid was needed to achieve the same results that borax provided. These studies also state that the use of 8 to 12% of borax mixed with 92 to 88% of salt produces a salt-glaze at cone 03 (1976° F.) on clays which otherwise would not have taken a salt-glaze at or below cone 1 (2050° F.) when common salt was used. The general methods of introducing borax or boric acid to the firing were by mixing them with the salt or by adding them to the firebox just previous to the salting.

In this study, three firings were conducted in which combinations of 95% salt to 5% boric acid, 90% salt to 10% boric acid, and 85% salt to 15% boric acid were used. Due to the inability to develop a standard in the firing procedures, (refer to Chapter IV) definite conclusions concerning the effect of boric acid cannot be made. It was noticed that because of the small granular size of the boric acid (40-60 mesh), there was incomplete combustion of the salting mixture. When boric acid was added prior to the application of the salt, only a small amount went into a vapor. A detail photograph shows that the glaze developed from 85% salt and 15% boric acid was smooth and high in gloss, with small orange-peel texture. Refer to page 87, plate 40.

Wetting the Salt

It is not known what the exact effect of the additions of water (H_2O) to the salt has on the action of the salting vapors or on the resulting salt-glaze. Rix (24:301) states that water vapor is necessary in the kiln's chamber to combine with the free chlorine, resulting in hydrochloric acid fumes; however, these fumes have no effect on the formation of salt-glazes. Parmelee (22:180) suggests that wetting retards the volatilization of the salt and lengthens the effectiveness of the vapors.

In this study the sodium chloride used to achieve a salt-glaze was wetted with about 5% water and added to the fireboxes. Variations in the granular size of the salt were not a control factor. A medium size rock salt, produced by the Morton Salt Company, was used as the major source of sodium.

Placement of the Salt

Wetted salt was placed in a salting scoop and added to the firebox through the burner ports (refer to Appendix A) in front of the four burners. About one and one-half pounds of wetted salt was used per scoop. Three firings were conducted where wetted salt was also added through the salting port in the arch of the kiln (refer to Appendix A). However, no advantage was observed through this procedure. The early firings required about 25 to 35 pounds of wetted salt to achieve the same glaze thickness. About firing number 16, only 12 to

15 pounds of wetted salt were required as the chamber of the kiln was becoming more and more saturated with salt from previous firings, and this allowed a greater amount of the required vapor to be present to achieve the desired glaze thickness. Firing number 22 required only nine pounds of wetted salt to achieve the desired thickness. Refer to page 90, plate 43. Firing number 25 required only ten pounds of wetted salt to achieve the desired glaze thickness. Refer to page 89, plate 42.

Effects of Rates of Cooling on Salt-Glazing

The rate of cooling and the type of kiln chamber atmosphere during cooling was also studied. Rix (24:301) states that rapid cooling to a dull red heat is advisable to reduce the formation of crystals.

In this study, the formation of glaze crystals was not noticed in either rapid or slow cooling conditions. It appeared that when slow cooling conditions prevailed, the salt-glazes were slightly smoother and less glossy than when rapid cooling was employed. This was due to small amounts of sodium vapor remaining in the kiln's chamber which continued the fluxing action for a short period of time, and the resulting salt-glaze was able to flow, reducing the size of the orange-peel texture.

When the kiln was cooled rapidly, an oxidation or re-oxidation atmosphere was present, which affected the salt-glaze colors. Iron oxide became olive green to green-brown, manganese dioxide became muddy brown, and copper changed to a low intense muddy green. These glazes developed a crackle, retained their gloss, and pronounced orange-peel texture.

Cooling the kiln's chamber slowly (about 50° F. per hour) was accomplished by closing the damper. This condition was held for six hours after which the kiln was allowed to cool normally. Slow cooling enabled a reduction atmosphere to be present during the soft stages of the salt-glaze. The resulting glaze colors and clay body colors are reported in Chapter IV. These glazes were smooth, losing some of their orange-peel texture, and were somewhat mat in appearance.

Effects of Refiring to a Higher and Lower Temperature on Salt-Glazing

Two experiments were conducted in which salt-glazed ware was refired in a different atmosphere and at a higher temperature.

A set of four cups, salt-glazed at cone 5 in an oxidation atmosphere, were refired in a reduction atmosphere to cone 9. The previously formed salt-glaze lost all of its orange-peel texture, became darker in color, and showed visual appearances of a luster quality formed on its surface. Refer to page 91, plate 44.

A set of four cups, salt-glazed at cone 8 in an oxidation atmosphere, were refired in a reduction atmosphere to cone 9. The previously formed salt-glaze began to lose its orange-peel texture and became darker in color. Refer to page 92, plate 45.

When refiring the salt-glazed ware to a temperature lower than that required during the salting process, no appreciable change was noticed in the nature or color of the glazes.

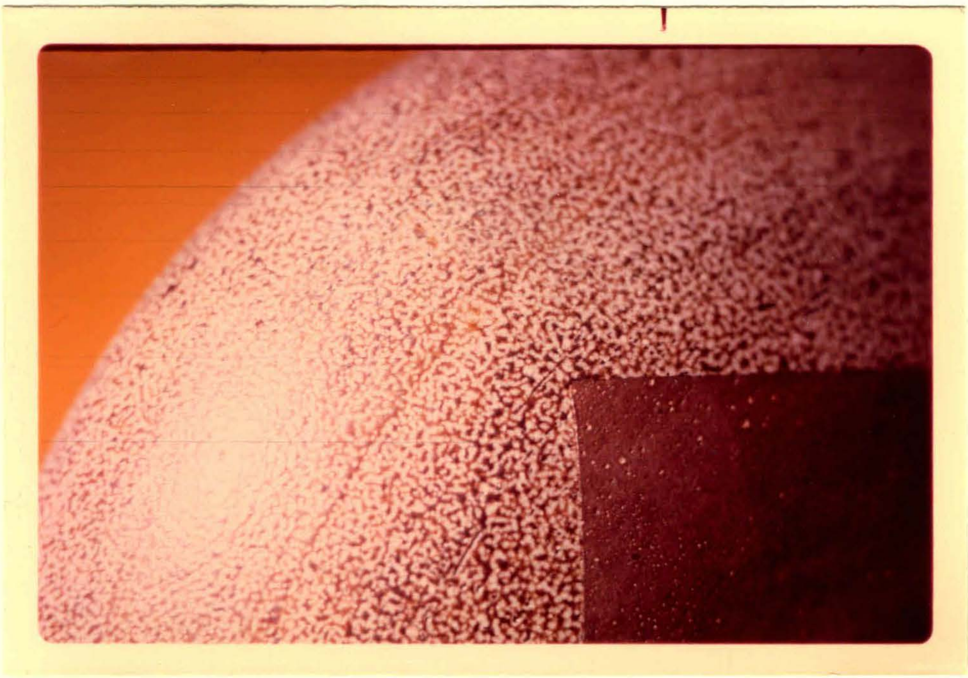

PLATE 40

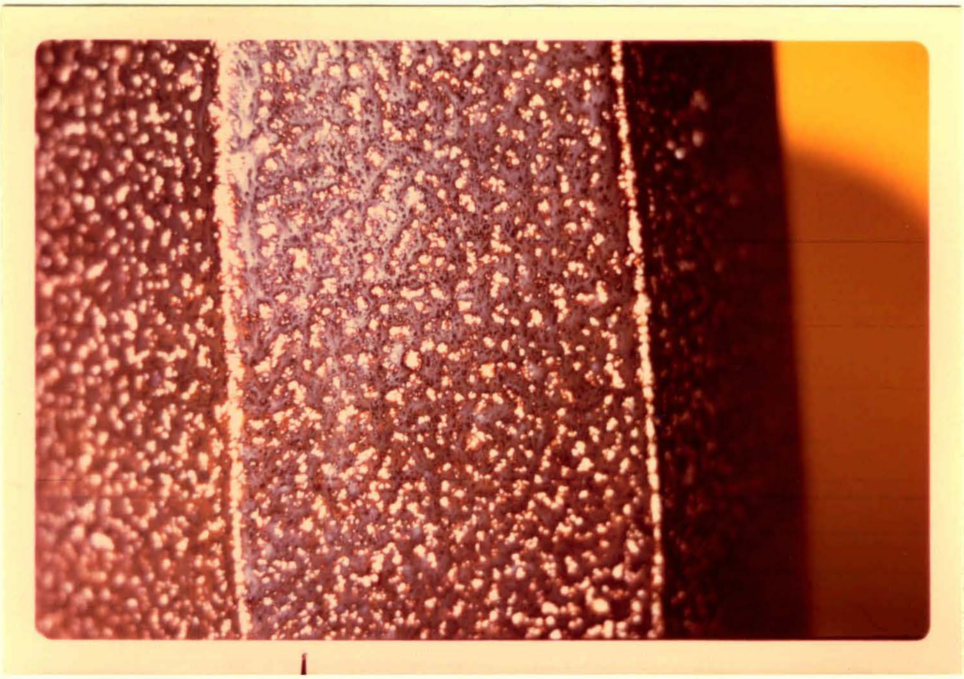

PLATE 41

PLATE 42

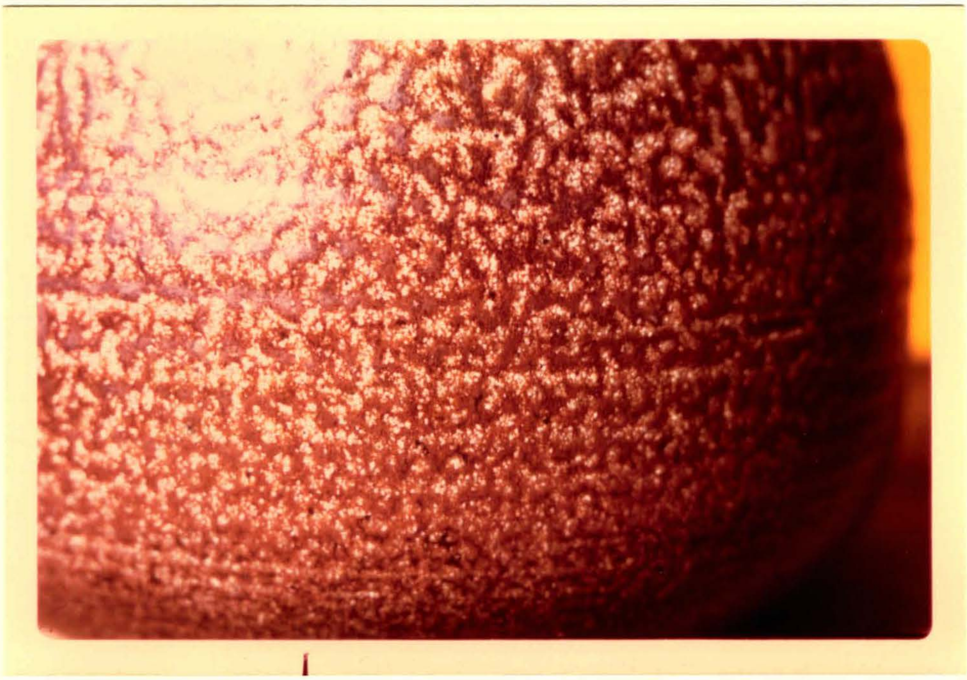

PLATE 43

PLATE 44

PLATE 45

CHAPTER V

SUMMARY AND CONCLUSION

In a review of the available literature pertaining to salt-glazing, it was noticable that a void existed in the quality and quantity of salt-glazing studies which deal with the problems confronting the artist potter. This study proposes to bridge the gap between the concerns of industrial salt-glazing studies, and the interest of the artist potter.

In this study, two types of stoneware clay bodies were used with variations in their silica, alumina, and alkaline content. Tests of these clay bodies were conducted to establish their forming characteristics, their ability to take a salt-glaze, and with the additions of metallic salts, the developed glaze and clay body colors.

Both stoneware bodies took a good salt-glaze at cone 5 and cone 8. The clay bodies with the highest percentages of coarse fire clay (Kaiser fire clay) took a salt-glaze dark in color with a rough orange-peel texture. Clay bodies with the highest percentages of fine fire clay (Masons Blend) took a salt-glaze light in color with a smooth orange-peel texture. Clay bodies high in silica showed no visual difference in their ability to take a salt-glaze over the clay bodies high in alumina (refer to Table I). Possibly the percentage range of silica content and alumina content was not wide enough to establish their effects on salt-glazing (refer to Chapter IV). Additions of silica sand to the clay bodies also showed no visual effects in the development of salt-glazing.

Clay bodies with additions of 3 to 6% iron oxide took a good salt-glaze with small to medium orange-peel texture, and medium gloss. These additions to the clay bodies caused a dark brown to dark grey clay body color.

Clay bodies with additions of 2% magnesium carbonate or 2% calcium carbonate took a good salt-glaze of good gloss and orange-peel texture. The clay bodies were light grey in color.

Clay bodies with additions of 4 to 6% dolomite took excellent salt-glazes of good gloss and orange-peel texture. The clay bodies were light grey in color.

The effects of various soluble and insoluble metallic salts were tested to establish a range of possible salt-glaze colors. The application of these salts was confined to a mixture of the desired salt or salts and water. These mixtures were brushed upon the surface of the biscuit ware and salt-glazed at cone 5 and cone 8 in both reduction and oxidation atmospheres.

The results of these tests are summarized in Table IV.

TABLE IV

THE EFFECTS OF VARIOUS METALLIC SALTS ON SALT-GLAZED COLORS

Metallic Salt	Glaze Color
Iron Oxide	Brown, Black-brown, Yellow-brown
Iron Oxide, Manganese Dioxide	Dark brown, Black-brown
Iron Oxide, Whiting	Warm brown, Dark brown, Yellow-brown
Iron Oxide, Rutile	Dark brown, Golden brown
Iron Oxide, Barnard clay	Black-brown, Yellow-brown
Iron Chromate	Black-brown, Black
Crocus Martis	Black-brown, Dark chocolate brown
Cobalt Oxide, Cobalt Carbonate	Bright blue
Cobalt Oxide, Copper Carbonate	Pale blue, Dark blue, Blue-green
Cobalt Oxide, Iron Oxide	Dark blue, Blue-brown
Cobalt Chloride	Pale blue, Pale blue-green
Manganese Dioxide	Dark brown
Uranium Oxide-Yellow	Yellow, Yellow-brown
Nickel Oxide	Black-brown, Black
Nickel Chloride	Dark brown, Black-brown
Cobalt Sulfate, Nickel Chloride	Grey-brown, Black-brown
Albany clay	Yellow-brown, Orange-brown
Molybdenum Trioxide	Dark brown, Dark red-brown
Amblygonite	Orange, Orange-brown
Chromium Nitrate	Rich brown, light brown
Zircopax	Creamy white
Zirconium Spinel	Golden brown, Light brown
Barium Carbonate	Translucent white
Raw Kaolin	Light brown, Rich brown

The effects of the kiln's atmosphere on the development of salt-glazing and the resulting colors of the glaze and clay bodies were studied under oxidation and reduction conditions.

Under oxidation conditions, the resulting salt-glaze colors were clear and glossy. The clay bodies were light brown to buff in color, and the orange-peel texture was small. Under these conditions, large amounts of salt were required to achieve the desired glaze thickness.

Under reduction conditions, the resulting salt-glaze colors were dark and low in intensity, with medium to good gloss and good orange-peel texture. The clay bodies were grey to grey-black in color, with small black spots covering the surface of the clay.

Various rates of cooling were studied showing that slow cooling allowed the glaze to smooth and become mat in appearance. Fast cooling caused the glaze to crackle and allowed the glaze to retain its gloss and pronounced orange-peel texture.

Additions of sodium carbonate and boric acid to the sodium chloride caused no change in the resulting salt-glaze colors.

Wetting the salt proved to be advantagous in reducing the rate of sodium chloride volitalization.

No observable advantage could be established when salt was introduced through the salting port in the kiln's arch as compared to introduction through the burner ports to the fireboxes.

The direction of this study has only begun to represent the scope of possible technical processes which may be accomplished in salt-glazing. In the development of clay bodies, the variations in clay forming constituents and metallic salts are only a beginning point. The scope of variations of metallic salts used to create salt-glaze colors was limited, however these studies suggested many possibilities which could be explored by individuals interested in salt-glazing.

Through the results of this study, a new world of surface embellishment and glaze color was realized. The processes involved in salt-glazing enable a true relationship to exist between the individual and the resulting effects. The action of firing the kiln, salting the kiln, and making adjustments according to one's emotional and metaphysical attitudes, allow for a level of personal involvement which is offered only through salt-glazing.

The fact that the resulting salt-glaze emanates from the surface of the clay objects, allowing not only a close physical relationship between the clay body and glaze, but a strong conceptual relationship which adds to the totality of the objects.

The physical properties and developed colors of salt-glaze are compatible to the physical properties and colors of the fired clay. The fire-striking hardness of the salt-glaze emulates the stone-like hardness of the fired clay. The grey to grey-brown colors of the salt-glaze resembles the earth colors of the fired clay.

Salt-glaze can reveal and accentuate the slightest change in contour, the subtleness of the clay texture, or the detail work on the clay surface. It can also create bold and striking patterns which may be used to complement or contrast the clay ware.

Salt-glazing adds to the beauty of clay wares, not in spite of the clay, but because of the clay. It depends upon the clay for its existence, and in return it enriches the clay surface and adds a quality of beauty not found in any other form of embellishment.

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APPENDIX A

Kiln Design and Construction

The design of a kiln which will be used for salt-glazing must comply with the general requirements of any high fire kiln but must also satisfy the specific demands of the salting procedures. Almost any type of kiln which will withstand the high temperature required could be used; however, the procedures used in salt-glazing can be best accomplished in a kiln with a down-draft design.

A down-draft kiln with an inside volume of twenty-seven cubic feet was used in this study. Not only does this size offer a large firing capacity, but because of the 3' x 3' x 3' dimensions, it alleviates many construction problems. The use of this design offered a firing box which was shielded from the firing chamber. It also developed a lazy atmospheric circulation which insured uniform heat and salt vapor distribution throughout the firing chamber.

Structural concrete blocks were used to form a foundation for the kiln. This type of block enabled ample weight support and allowed for air circulation which reduced the danger of heat destruction. Two sizes of concrete blocks, 6" x 8" x 16" and 4" x 8" x 16" were used in the construction to allow for the flue design and floor design of the kiln. Refer to page 108, front elevation. The blocks were loosely stacked to allow for slight movement, due to thermal expansion and contraction.

Construction of the kiln's floor and well-hole type flue, consisted of two courses of hard firebrick. Expansion joints, a space of about one-fourth inch between every fourth or fifth brick, and leveling, were checked at this stage. The floor and flue design allowed for easy replacement of the damaged bricks in the firing ports, fireboxes, and firing chamber. Refer to page 108, front elevation, and page 109, floor elevation.

The main walls and stack were constructed simultaneously. The corners were established first, with bricks being added later to complete each course. Exact measurement and the use of a construction level assured that the walls were straight. Four burner ports, two on each side, measuring 4" x 5" and designed with a lintel type arch were incorporated into the side walls. Bricks for subsequent courses were placed to overlap the joints of the bricks below. This added to the strength and tightness of the enclosure. One course of bricks was placed perpendicular to the firing chamber, to act as a stretcher or brace section. This added strength to the construction and tied the interwall to the outerwall. Refer to page 108, front elevation.

The main arch of the firing chamber was constructed using Number 1 wedge bricks. A plywood form was used to support the weight of the constructed arch, and as a guide in developing the appropriate rise for the span. A salting port was incorporated into the arch by suspending one brick between two courses of wedge brick, creating a small hole, 2" x 4", which was covered by laying a soap brick over the top. The door arch was constructed in the same manner, using Number 1 arch bricks, and a feather edge skewback.

Bricking continued past the main arch skewbacks, allowing for a space which was filled with diatomaceous earth; this added increased insulation for the arch. Refer to page 108, front elevation.

The design of the stack called for a structure with a 9" x 9" inside dimension, and rising a minimum of eighteen feet. This offered the necessary size requirement for a kiln of 25 to 40 cubic feet displacement. The front side of the stack acted as both a wall for the stack and an insulation wall for the kiln's chamber. This reduced the number of required bricks for construction, helped to pre-heat the stack for better draft and aided in the vertical support of the stack. About two feet above the foundation, two bricks were offset to create a damper slot. Two wedge bricks were used at the bottom of the stack, which could be removed to allow for clean-out, and a place to pre-heat the stack for drawing. Refer to page 110, side elevation. The stack was constructed with soft firebrick to the sixteen foot level, where red clay flue-liners continued to complete the structure to a height of twenty-two feet. This top section was loosely stacked, surrounded by a metal shield which offered the necessary vertical and horizontal support. Diatomaceous earth was packed between the flue-liners and the metal form for insulation.

A kiln shelf was used as a sliding damper. To standardize the damper opening, a calibration system was used. Calibration marks, placed on the back of the kiln, referred to the number of inches which were available in the stack's chamber. By drawing the damper to a position of six, meant that a 6" x 9" drawing space was being used.

The kiln door was loosely stacked in place for each firing. This eliminated the necessity to construct heavy metal supports and hinges and offered flexibility in the arrangement needed for each firing. The door design and construction allowed for a peep-hole and test-ring removal hole. Wet clay was used to seal the parts of the door which did not fit perfectly with the door arch.

Sixteen hard firebricks were used to construct each bag wall. The walls were loosely stacked and placed six inches in from the chamber's side walls. The bag walls created a firing box where the salting volatilization occured, and they deflected the heat and salt vapors toward the top of the kiln's firing chamber. Refer to page 109, floor elevation.

Four venturi-type atmospheric burners were placed about three inches inside the firing ports which allowed the necessary space for gas combustion. Each burner was equipped with a gas valve and a primary air control valve. The construction allowed easy removal of the burners for cleaning purposes. The orifice of each burner was drilled out to a one-fourth inch opening which offered the necessary gas volume.

One of the major considerations in the design of a salting kiln was the type of firebrick used for construction. The bricks must be able to withstand the high temperatures required in salt-glazing, offer the necessary insulation and heat retention qualities, and must be partially resistant to the attack of the sodium vapors.

Several high-alumina refractories were studied to determine the type of brick which would comply to the characteristics required.

It was decided to employ a 60% alumina firebrick. This brick had a P. C. E. value of 36 to 37 with the corresponding softening temperature of nearly 3300° F. and offered the necessary resistance to the attack of the sodium vapors. A refractory of 70 to 99% alumina was not used because it was too resistant to the chemical attack. The 60% alumina refractory allowed some deposit of sodium gasses which aided in the salting process, but did not show the signs of deterioration which were evident when semi-silica firebricks were used. Refer to page 113, plate 56.

The bricks specified to construct the interwalls of the kiln were "Anchor," and "Anchor dash," brands manufactured by the Harbison-Walker Refractories Co., and supplied by the Fire-Brick Supply Co., Seattle, Washington.

A soft firebrick refractory was used to complete the outerwalls of the kiln and the upper section of the stack. Because these refractories were not exposed to the direct heat of the kiln's chamber, bricks with a P. C. E. Value of 5 to 8 were selected. These refractories had a brand designation of H-W 20 and H-W 23, are also manufactured by the Harbison-Walker Refractories Co., and supplied by the Fire-Brick Supply Co., Seattle, Washington.

Considerations for the kiln furniture centered around the use of a 90% alumina refractory. The material used to form the shelves had to have a very high resistance to the sodium vapors and had to offer the necessary strength to retain their shape during the firing. The brand name of Hartile KXD castible was used to form the 10" x 20" x 1" kiln shelves. Korundal XD soaps, 9" x 2-1/2" x 2-1/4", were used as stacking posts. Both of these refractories were manufactured and supplied by the firms mentioned above. Refer to page 111, plate 54.

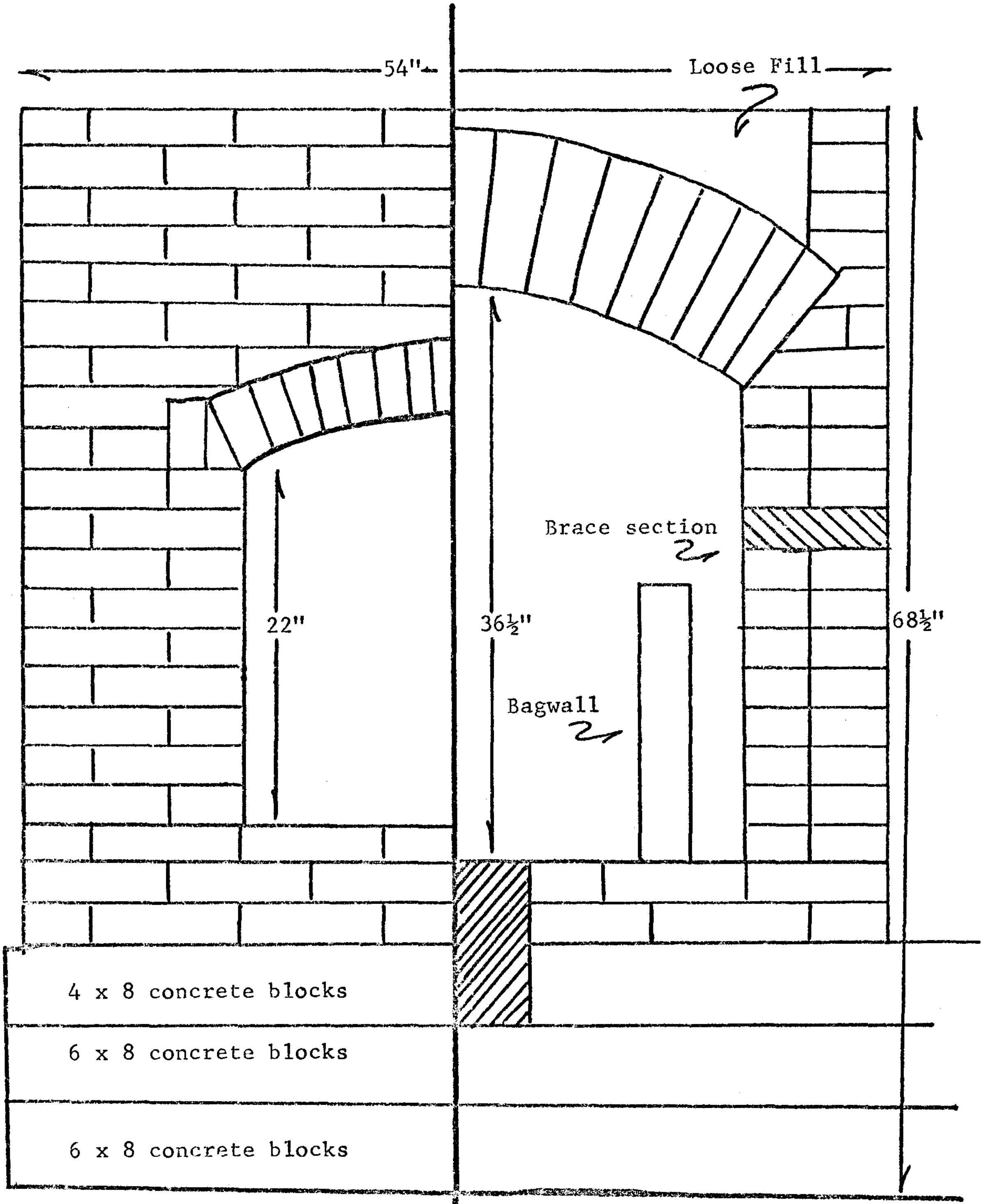
Metal work was required to catch the thrust of the main arch, and to supply both vertical and horizontal support to the kiln. Refer to page 112, plate 55.

The following table is a list of the materials used in construction of the salting kiln, and their approximate cost factor.

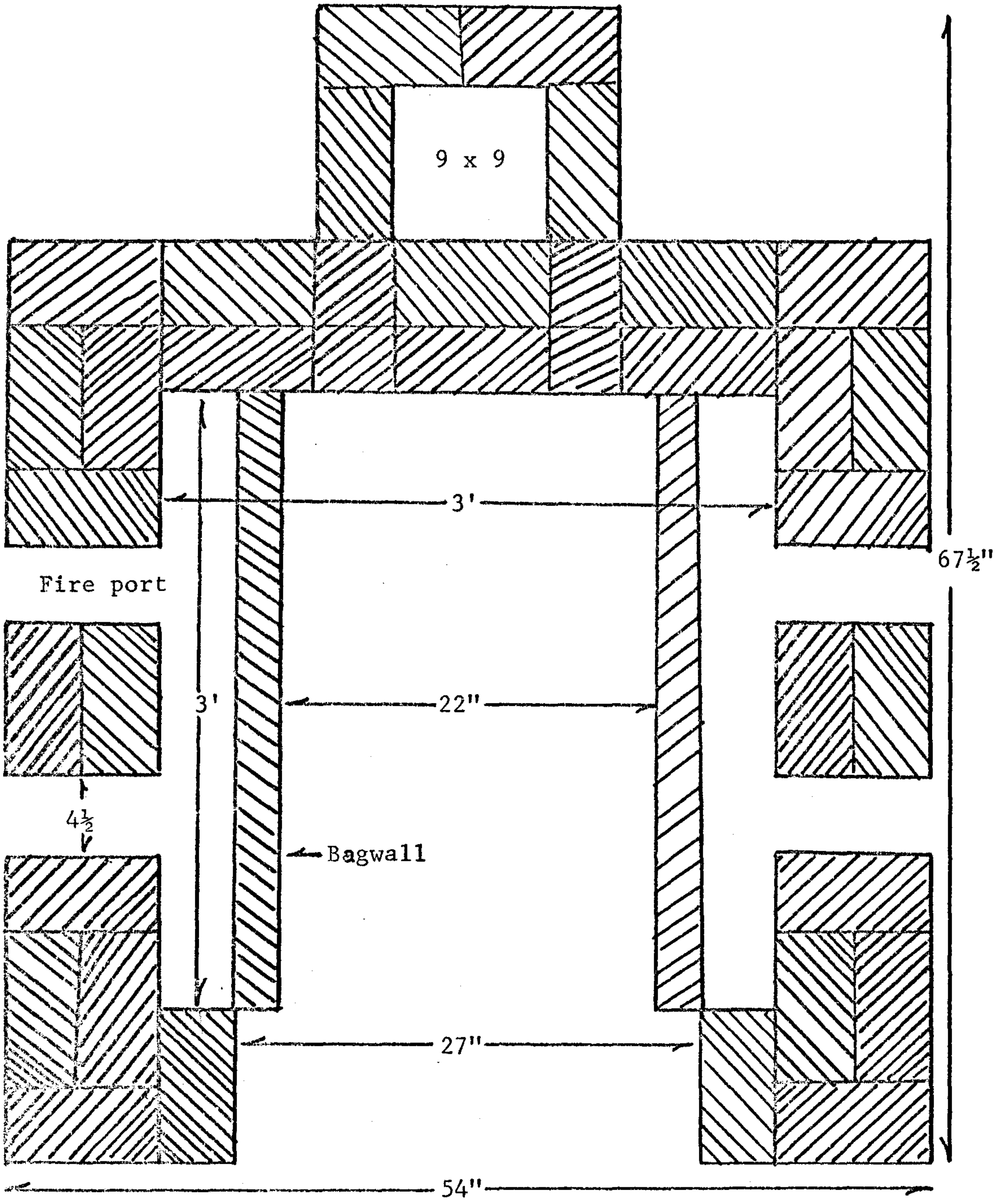
TABLE V

MATERIALS AND COST FOR THE CONSTRUCTION OF A DOWN-DRAFT KILN

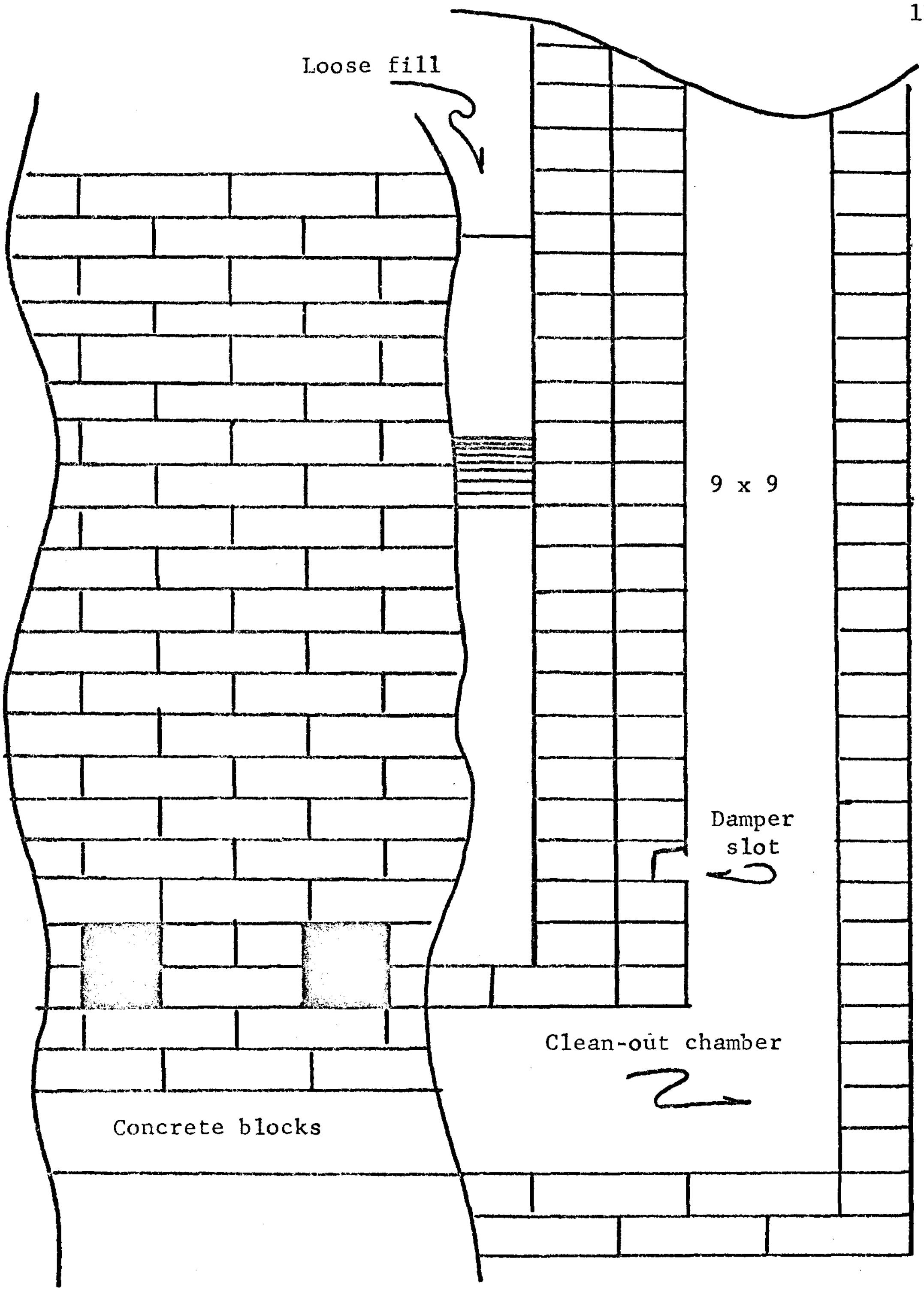
Quantity	Materials	Cost
35 each	Concrete Blocks, 4" x 8" x 16"	$ 10.00
80	Concreate Blocks, 6" x 8" x 16"	25.00
615	H-W Straights (Anchor)	443.00
175	H-W Wedge #1 (Anchor)	133.00
20	H-W EndSkew (Anchor)	14.00
20	H-W SideSkew (Anchor)	14.00
20	H-W Soap (Anchor)	13.00
2	H-W Feather Edge (Anchor)	1.25
12	H-W Arch #1 (Anchor)	8.50
50	H-W 23 (Insulation)	20.50
700	H-W 20 (Insulation)	251.00
100 pounds	H-W High Alumina Castable	12.75
10 each	H-W Hartile KXD Shelves	140.00
20	H-W Korundal XD Soaps	60.00
4 each	Venturi Burners	25.00
2 sheets	3/4" Plywood	10.90
1 piece	Channel Iron 5" x 1" x 1/4"	9.65/cwt
2	Channel Iron 2" x 1" x 1/8"	9.65/cwt
4	Angle Iron 1-1/2" x 1/8"	9.65/cwt
1	Angle Iron 2-1/2" x 1/8"	9.65/cwt
2	Steel Rod 1/2" x 20'	9.50/cwt
		$ 1,292.00



FRONT ELEVATION



FLOOR ELEVATION



SIDE ELEVATION

PLATE 54

Down-Draft Kiln, Inside View

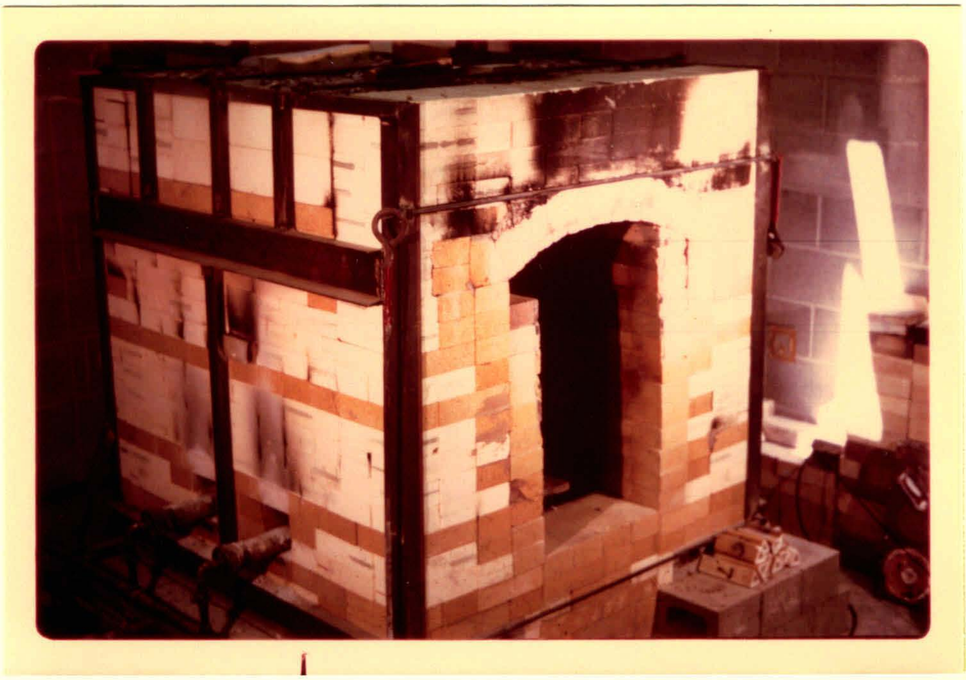


PLATE 55

Down-Draft Kiln, Outside View

PLATE 56

Right, High-Alumina Firebrick

Left, Semi-Silica Firebrick

APPENDIX B

Typical Firing Schedule at Cone 5 in a Reduction Atmosphere

A typical firing schedule for the salting kiln described in Appendix A, and used in this study to achieve a salt-glaze at cone 5 in a reduction atmosphere is as follows:

1. The kiln was stacked with the prepared biscuit ware, the day before the salting was started. The work was arranged in the kiln to allow the salting vapors ample circulation through the entire kiln chamber.

2. At 6 p.m., the door of the kiln was set into position and the four burners were ignited. In down-draft kilns, which do require a stack for draft, it is necessary to start this action. The damper was fully opened, and a fire was built with burning paper in the clean-out hole in the base of the stack. Once sufficient heat was moving up the stack, drawing continued throughout the firing. The burners were set at 1/8 gas opening, and the firing continued throughout the night.

3. 8:00 a.m., day of salting. The kiln's chamber had reached a temperature of 1100° - 1200° F., due to the overnight burn. The gas valves were then opened to a position of 1/4 open.

4. 11:00 a.m. The kiln's chamber had reached a temperature of 1600° - 1700° F., (about cone 010) at which time the reduction of the clay body was accomplished by opening the gas valves to 3/4, closing the primary air controls to 1/2 turn open, and closing the damper to 3 inches. This condition was held for half an hour; then the

settings were changed to a gas valve opening of 1/2, primary air controls opened to full, and the damper was opened to six inches.

5. 2:00 p.m. The kiln's chamber had reached a temperature of 2050° - 2100° F. The gas valves are opened to 3/4.

6. 4:00 p.m. The kiln's chamber had reached a temperature of 2150° - 2160" F. (cone 5), and salting was started. To insure a good reduction atmosphere, the gas valves were opened to full, the primary air controls were shut completely, and the draft damper was moved to a position of 2-1/2", this condition was held for three minutes, after which the primary air controls were opened to one-full turn. This retained a reduction condition, however it was more efficient flame.

7. 4:15 p.m. The salting mixture was added to the fireboxes by the use of a salting scoop. Under the reduction atmosphere, it took about four minutes for the salt to volotilize and to dissipate throughout the kiln's chamber. Firing continued for about 5 - 7 minutes to regain the temperature lost during the salting. Saltings were continued as discribed above until the desired glaze thickness was determined by examining the test rings periodically removed from the firing chamber.

8. 5:30 p.m. The salting was completed and the kiln prepared for cooling. Slow cooling required the complete closure of the damper for about four hours. For normal cooling conditions, the damper was placed at a position of 3 inches. For fast cooling conditions, the damper was placed at a position of 8 inches.

Typical Firing Schedule at Cone 8 in an Oxidation Atmosphere

A typical firing schedule for the salting kiln described in Appendix A and used in this study to achieve a salt-glaze at cone 8 in an oxidation atmosphere is as follows:

1. The kiln was stacked with the prepared biscuit ware, the day before the salting was attempted. The work was arranged so as to allow the salting vapors ample circulation through the entire kiln chamber.

2. At 6 p.m., the door of the kiln was set into position, and the four burners were ignited. The burners were set at 1/8 gas opening, and firing continued throughout the night.

3. 8:00 a.m., the day of salting. The kiln's chamber had reached a temperature of 1100° - 1200° F., due to the overnight burn. The gas valves were opened to a position of 1/4.

4. 11:00 a.m. The kiln's chamber had reached a temperature of 1600° - 1700° F. The gas valves were opened to 1/2, and the damper was opened to a position of 6".

5. 1:00 p.m. The kiln's chamber had reached a temperature of 2000° - 2050° F. The gas valves were opened to a 3/4 opening.

6. 3:00 p.m. The kiln's chamber had reached a temperature of 2350° - 2370° F. (cone 8), and salting was started. To insure a good oxidation condition throughout the salting procedure, the gas valves were held at a 3/4 position, the primary air controls were opened to full, and the damper was opened to a position of 8".

7. 3:15 p.m. The salting mixture was added to the fireboxes by

the use of a salting scoop. Under oxidation conditions, it took about 1-1/2 minutes for the salt to form a vapor and dissipate throughout the kiln's chamber. Firing was continued for about 5 minutes to regain the temperature lost during the salting procedures. Salting was continued as discribed above, until the desired glaze thickness was achieved by examination of the test rings as they were removed from the firing chamber.

8. 5:00 p.m. The salting was completed and the kiln was prepared for cooling.

Minor Considerations for Salt-Glazing

It was found that the salt vapors had no effect on feldspathic glazes. These glazes were used to cover the interior of wares and as decoration on the surface of the wares. As long as the feldspathic glaze was fired to maturity, it was compatible with the salt-glaze.

Albany slip glaze was used to cover the interior of many wares, and as decoration on the surface of the wares. No adverse effects were noticed on the Albany slip glaze in combination with salt-glazing.

To insure that the glazed ware did not adhere to the kiln's shelves, a plastic mixture of 70% alumina hydrate, and 30% fire clay was used as pads between the clay wares and the shelves. Mixtures of 70% alumina hydrate - 30% ball clay, and 70% alumina hydrate - 30% Jordan clay were also used with good results.

Test rings were made of the same type of clay as was used for the clay wares. It was found that the test rings should be placed toward the bottom of the firing chamber. If these rings showed a good salt-glazing occuring at the lower regions of the kiln, it could be assumed that a good salt-glaze was occuring in the upper sections. Refer to page 119, plate 57.

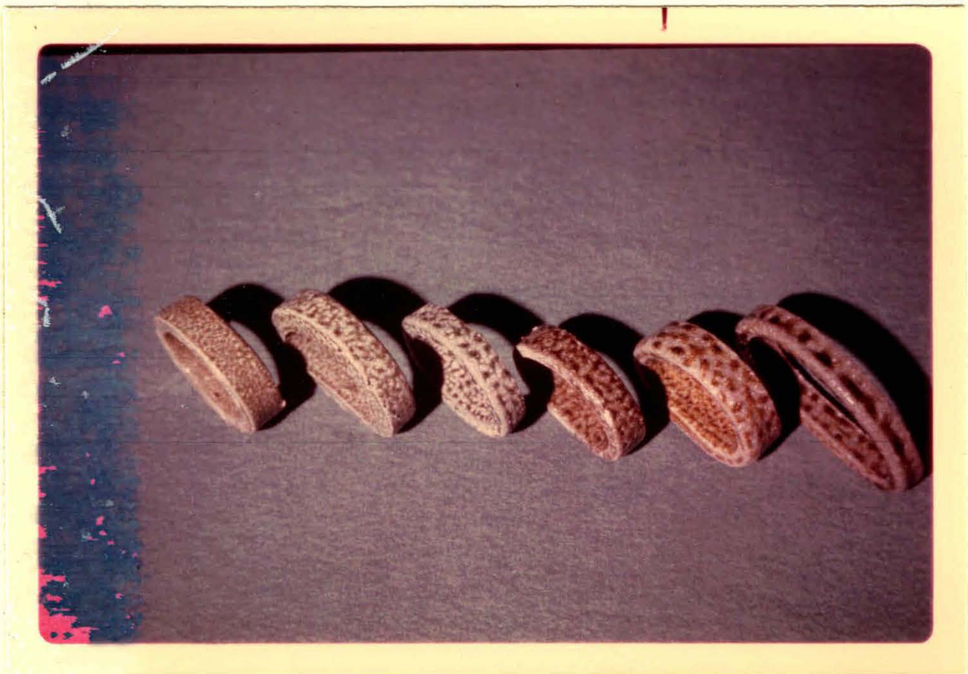


PLATE 57