

SALT GLAZING IN A CATENARY ARCH KILN

by

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INTRODUCTION

The purpose of this study was to determine the plausibility of salt glazing in a catenary arch kiln. The study was limited to kiln construction and its operation, and to ware production which characterized the simple, direct quality inherent in salt glazing. Background material was obtained from three major sources: library collections of Kansas State University and the University of Kansas, personal correspondence with potters who have worked with salt glazing, and personal experience.

The salt-glazing process is an inexpensive means of obtaining a hard, but handsome, glaze for stoneware. The salt-glazing industry flourished in Europe during the 17th and 18th centuries, and produced items such as ceramic utensils, beer mugs, and storage jars. The industry was active in America during the colonial period. Today, however, salt glazing, on a large scale, is confined to industrial materials.

Salt glazing presents unlimited possibilities to the studio potter for the production of ware which is intrinsically charming. Because the potter needs a separate kiln for salt glazing, the catenary arch design affords the potter a rugged, maintenance-free kiln.

A personal, critical analysis has been given of this writer's pottery designed during the time of this research.

REVIEW OF LITERATURE

History of Salt Glazing

The origin of salt glazing is vague, but most authorities agree that the process was discovered by accident. The stoneware industry was prosperous during the 15th to the 17th centuries in Germany, and most of the early German salt-glazed ware dates from the 16th century; however, H. G. Schurecht (1943) states that the salt-glazing process dates to the 12th century in northern Germany around Aachen.¹ During the 1600's, salt glazing began in England, and it is believed that the vapor-glazing process came to America during the early colonial period.

In his Primer, Salt Glazed Stoneware, Edwin A. Barber (1907) describes the styles, colors, and decorations of early German, English, and American salt-glazed ware. The earliest center of German salt-glazed ware was at Siegburg, near Bonn, in the 15th century. There, a coarse, brownish-gray stoneware was produced and incorrectly called Cologne ware because the market was in Cologne. The Siegburg ware shapes were basically tall, cylindrical wine bottles and globular jugs with hand-finished bases, decorated with medallions and biblical subjects. The glaze was usually very thin and sometimes absent.

Yellowish-brown bodied jugs and wine bottles with reddish-brown, smooth glazes bearing dates of 1539, were produced at Raeren in Flanders.

¹H. G. Schurecht, "Salt Glazing of Ceramic Ware," American Ceramic Society Bulletin, 1943, 22:45.

Frechen ware, decorated with grotesque masks and imitation coins, had a brown body and brown glaze. The wire markings on the base of the ware indicate that the ware was cut from the wheel, unlike the Siegburg ware which was torn from the wheel.

Brown stoneware mugs and jugs, decorated with figures and geometric patterns in applied relief, from Kreussen, date from the middle of the 16th century.

Gray clay-bodied mugs, bottles, and jugs, with incised and applied relief patterns, were manufactured at Höhr and Grenzhausen during the 17th, 18th, and 19th centuries.² Höhr-Grenzhausen is among the few remaining communities doing salt glazing today.³

Bouffieux ware became firmly established late in the 16th century in an area which is now Belgium. The clay bodies were brown with irregular brown glazes and decorated with masks and medallions. Large and small barrels, kitchen utensils, and jugs made up the inventory of Bouffieux ware.⁴

Salt glazing was introduced in England during the Elizabethan period, but it reached its height during the 18th century. John Dwight obtained from Charles II patents for the manufacture of stoneware, including salt glaze, for his pottery at Fulham. Fulham ware was styled in the manner of Frechen ware. In 1693, Dwight began legal action against Aaron, Richard,

²Edwin A. Barber, Salt Glazed Stoneware, 1906, pp. 12-13.

³Angelo C. Garzio, "German Salt Glazing," Craft Horizons, March/April, 1963, 23:20.

⁴Barber, op. cit., pp. 14-16.

and Thomas Wedgwood for what Dwight claimed to be violations of his patents. The records of the suits show proof that ware of the Fulham style was produced in Staffordshire before 1700.⁵ Staffordshire ware remains as the prominent example of English salt glaze. Barber describes English salt glaze this way:

The term "salt glaze" has been applied to an English product, a true stoneware of white body, thin and graceful in appearance, so highly fired as to be translucent in its thinnest parts, covered with an exceedingly hard saline glaze, which first appeared in Staffordshire near the close of the 17th century.⁶

The desire to find ways of producing Chinese porcelain led Staffordshire potters to the production of a light colored, salt-glazed stoneware. In 1710, Thomas Wedgwood made a buff-colored ware decorated with raised designs. By 1720, Ashbury added calcined flints to a light-colored clay to develop a white clay which failed to imitate porcelain, but instead, he produced a hard, strong stoneware capable of being moulded with great fineness and precision. "Scratch ware," dated from 1740, was colored by incising designs on the ware and dusting it with powdered cobalt, or rubbing cobalt into the scratches.

By 1750, salt-glazed "...teapots were often made in the most fantastic shapes such as houses, camels and pecten shells."⁷

By about 1770, the manufacture of white salt-glazed stoneware had almost ceased, cream coloured earthenware having become firmly established by then.⁸

⁵ Bernard Rackham, Early Staffordshire Pottery, 1951, pp. 19-27.

⁶ Barber, op. cit., p. 20.

⁷ Griselda Lewis, English Pottery, 1956, explanations of figures 93-94.

⁸ Loc. cit.

Although potteries were producing wares in the United States as early as 1684, it is unlikely that salt glazing was done for ten to thirty years later.⁹ Early American salt-glazed products were

...ware of a rude and simple character, in the forms of crocks and jars and other utilitarian articles, entirely devoid of ornamentation save an occasional dash of blue or, in exceptional cases, a few roughly incised ornaments.¹⁰

Late in the 18th century, Paul Cushman manufactured stoneware near Albany, New York, which had a brownish body, and was limited in cobalt decoration. Most Early American salt-glazed ware had the brownish-gray body with the extensive use of cobalt blue decoration.¹¹ Barber however, gives credit to a woman for combining artistic elements with utilitarian ceramic craft.

It was reserved for a woman, however, to breathe the breath of artistic life into the body of American stoneware, and under her deft touch, guided by refined instinct and inventive genius, the old utilitarian forms were converted into new and graceful shapes...The honour of raising the humble manufacture of salt-glazed ware in this country to a place beside the finer ceramic arts belongs to Mrs. S. S. Frackelton.¹²

Technical Aspects of Salt Glazing

W. P. Rix listed important considerations which influence the success of salt glazing.

⁹John Ramsay, American Potters and Pottery, 1949, p. 39.

¹⁰Barber, op. cit., p. 24.

¹¹Ibid., p. 25.

¹²Ibid., p. 27.

- (1) Since the action of salt takes place only on siliceous particles, highly siliceous clays are necessary.
- (2) The ware body must be at a point of incipient vitrification before glazing.
- (3) Once the surface of the ware has been vitrified, no further change in condition can take place no matter how much the temperature of firing or the quantity of salt is increased.
- (4) When salt is introduced into the kiln, the temperature will drop rapidly; therefore, salting should be done in series to allow the temperature to rise after each salting.
- (5) Some means of introducing water into the kiln at the time of salting is necessary to provide for the union of water vapor and the free chlorine.
- (6) Cooling must be rapid to a dull red heat to prevent crystallization, then slowed to prevent dunting.¹³ (Dunting--cracking of ware during kiln cooling period caused by strains between glaze and body.)

J. O. Everhart (1930), in an effort to find ways to reduce the cost of production of sewer pipe, conduit, face brick, and building tile, used various concentrations of salt in slips (clay suspended in water) to produce a salt glaze. Salt glazing by the normal method of introducing salt into the kiln at the maturing temperature was restricted to periodic kilns. Everhart worked on a process of salt glazing in tunnel and chamber kilns,

¹³W. P. Rix, "Notes on Vaporous Method of Glazing Pottery," Literature Abstracts of Ceramic Glazes, 1951, p. 301.

as well. Initially, he applied sodium chloride alone on the ware, but found that too much volatilization took place before a proper temperature could be reached for the formation of glass. The salt alone caused a darkening of the surface, an undesirable feature for his experiment. Buff clays were darkened to browns; pink, or salmons, to deep red. The change in color was caused by the increased vitrification on the ware surface. Various results were found, depending on the percentage of salt combined with the slip. Low amounts of salt in the slip did not produce a glaze; however, there were delightful color and surface effects. (The author did not mention what color resulted.) When forty parts, or more, of salt to one hundred parts of slip were used, a violent reaction occurred between the salt and the clay body which caused boiling, peeling, and crawling of the glaze. When thirty, to thirty-five, parts of salt to one hundred parts of slip were used, glazes with smooth, gloss-like surfaces were produced and were considered to be better than the glazes produced by introducing salt through the fire box. It was necessary to grind both the slip and the salt products to acquire a smooth surface.

Metallic oxides were added to alter the color combinations of the final ware. Manganese dioxide produced browns; chrome oxide, greens; lime tended to develop greenish tints.

Everhart concluded from his test that any clay or shale having a maturing temperature of cone 1 (2109° F), or higher, could be salt glazed by a coating of slip containing sodium chloride.¹⁴ (All cone temperature

¹⁴J. Otis Everhart, "Production of a Salt Glaze by the Application of a Slip to the Ware," American Ceramic Society Journal, 1930, 13:399-403.

equivalents based on Orton Pyrometric Standard.)

As a result of Everhart's experiments, Marion L. Fosdick (1934) did research in salt glazing at cone 02 (2048° F), by slip application. The purpose of his experiment was to produce a self-glazing body, a product which could be fired at faience temperatures--temperatures used to fire lead-tin glazed earthen ware (about cone 02)--in an oxidizing atmosphere with other ware, and to obtain a palette of colored clays from the process. Three clay bodies were developed with basic ingredients of Enfield Red clay, Sagger clay, and Monmouth clay, respectively (table 1). Four slips--blue, black, dark blue, and light red--were used (table 2). The ware was formed, forty percent sodium chloride was added to the slip, the slip was applied, and the ware was fired. He found that lead glazes could not be fired with the salt-glazed ware. Dry patches and stripping of glaze on lead-coated ware were caused by air currents passing through the muffle. Colemanite and soda glazes were not adversely affected by the salt glaze.¹⁵ Parmelee stated that since lead compounds volatilize freely, lead-coated ware may exhibit impoverishment of glaze and loss of gloss unless enclosed in a suitable container during firing.¹⁶ (It appears from Fosdick's statement that the lead-coated ware did not glaze because air currents passed through the kiln and not because of any reaction with the salt.)

¹⁵Marion L. Fosdick, "Salt-Glazing at Cone 02 by Slip Application," American Ceramic Society Journal, 1934, 17:219-220.

¹⁶Cullen W. Parmelee, Ceramic Glazes, 1951, p. 223.

Table 1. Red and white body compositions.*¹⁷

Red body	:	White body
Enfield R - - - - -	83.4	Sagger clay (H1) - - - - - 70.9
Buckingham feldspar - - - - -	8.3	Buckingham feldspar - - - - - 7.1
Flint - - - - -	8.3	Monmouth clay - - - - - 17.7
		Flint - - - - - 4.3

* Third body not shown.

Table 2. Colored slips.¹⁸

Blue	:	Dark blue	:	Black	:	Light red
Body B - - - - 96		Body B - - - - 94		Body A - - - - 97		Body B - - - - 90
CoCO ₃ - - - - 4		CoCO ₃ - - - - 6		CoCO ₃ - - - - 3		Enfield R - - 10

H. F. Dingleline (1932) did experiments with clay of low vitrifying temperatures to produce salt glazes on sewer pipes, fittings, and wall copings. Clay, which vitrified at cone 02, could be salt glazed by raising the temperature rapidly, for short intervals, by combustion of soft-wood shavings combined with salt, and placed in the fire box. Although a reducing atmosphere was created by the rapid combustion of wood shavings and salt, there was a temperature rise lasting for ten or fifteen minutes. The process was repeated at half-hour intervals until three or four rounds of wood and salt were added. The rapid temperature rise of sixty to eighty degrees Fahrenheit, for short periods of time, did not cause the ware to deform, but

¹⁷Fosdick, loc. cit.

¹⁸Loc. cit.

the reducing atmosphere caused a darker surface on the ware.¹⁹

Investigations have been made using borax and boric acid as additives to salt in the salt-glazing process. The use of borax in the salt-glazing process has given glazes a higher gloss, reduced the danger of crazing, and in some cases, lowered the glazing temperature. Borax may be introduced into the kiln in combination with the salt or added separately.²⁰

H. G. Schurecht and K. T. Wood (1942) made extensive tests with borax and boric acid and found that all glaze properties were improved, including increased glaze thickness, smoother surface, better color, and less crazing. It was determined that best results were obtained by salting with salt alone in the first three saltings, followed by a combination of salt and a boron compound for the fourth salting, and finally, salting with a boron compound alone in the last salting. The poorest results were produced using the reverse of this order. It was also determined that clays which overfire at cone 1 could not be salt glazed with salt alone, but could be glazed by adding borax to the salt. Table three presents results of part of their laboratory work.²¹

The findings of Dingleline, Everhart, and Fosdick, on salt glazing at lower temperatures, were substantiated by H. D. Foster (1942). Foster made tests with slips which had lower maturing temperatures than the clay body

¹⁹H. F. Dingleline, "Salt Glazing a Clay of Low Vitriifying Temperature," American Ceramic Society Journal, 1932, 15:82-83.

²⁰Anonymous, "Borax-Salt Mixture Improves Appearance of Salt-Glazed Ware," Ceramic Abstracts, 1939, 19:236-237.

²¹H. G. Schurecht and K. T. Wood, "The Use of Borax and Boric Acid Together with Salt in Salt Glazing" (1942), Literature Abstracts of Ceramic Glazes, pp. 360-362.

Table 3. Results of laboratory work. 22

Improvement desired	Mixtures producing best results	Improvement made
1. To decrease salt glazing temperature	(a) Use 4-8% B ₂ O ₃ and 92-96% salt.	Decreased temperature 180° F.
	(b) Use 6-10% Borax and 90-94% salt.	Decreased temperature 144° F.
2. To increase glaze thickness	(a) See above.	(a) At cone 03, thick. > 29-450% At cone 2, thick. > 23% At cone 6, thick. > 11%
	(b) Use 7-12% Borax and 88-93% salt.	(b) At cone 03, thick. 43-114% At cone 2, thick. 49-88% At cone 6, thick. 36-41%
3. To darken salt glaze color	(a) Use 15% B ₂ O ₃ and 85% salt.	(a) Color changed from brown to dark mahogany
	(b) Use 15% Borax and 85% salt.	(b) Ditto (a), only not so marked
4. To overcome dull spots in salt glaze	(a) Use 10-15% B ₂ O ₃ and 85-90% salt.	(a) Dull spots gone, glaze brighter
	(b) Use 10-15% Borax and 85-90% salt.	(b) Spots gone, but glaze not so bright as (a).

22 Ibid., pp. 360-361.

and achieved satisfactory results. His tests with a salt-borax combination confirmed claims that the glaze brilliance was improved and that there was less crazing.²³ (It is the opinion of this writer that the improved glaze effects were caused by the properties of borax--reduces the viscosity of glazes and acts as a flux on silica.)

Authorities disagree on the type of atmosphere which should be used in salt glazing. An anonymous author, in Ceramic Age (Aug., 1948), cited three German technicians who have opposing views. Hauser held that an oxidizing atmosphere should be maintained throughout the firing process. Dorfner claimed that the reverse is best. Fukall favored an oxidizing atmosphere throughout the firing cycle to produce a denser, blister-free, natural-colored glaze.²⁴ C. R. Austin and J. O. Everhart (1930) claimed best results with an oxidizing atmosphere throughout the firing, salting, and cooling periods.²⁵ Foster agreed that an oxidizing atmosphere should be used. Foster's investigations revealed that an entirely different glaze was produced from a reduction firing. The resulting glaze was rough, contained holes, and was intensely colored.²⁶

The authorities mentioned above, who favor the oxidizing atmosphere, have worked primarily with commercial ceramic engineering projects, but it

²³H. D. Foster, "Salt Glazes on Structural Clay Building Units," Ohio State University Engineering Experiment Station Bulletin 113, 1942, pp. 36-37.

²⁴Anonymous, "Kiln Atmosphere in Salt Glazing," Ceramic Age, August, 1948, p. 82.

²⁵C. R. Austin and J. O. Everhart, "Production of a Gray Salt-Glazed Ware," Ceramic Abstracts, 1933, 12:196.

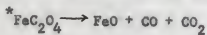
²⁶Foster, op. cit., p. 37.

will be noted later that the studio potter will favor a reducing atmosphere, particularly during the salting period.

An investigation by R. K. Hursh and E. C. Clemens (1931) showed numerous color possibilities while using different clay bodies (table 4).

Table 4. Body compositions.²⁷

Batch	A	B	C	D	E
Feldspar	10.2	9.8	9.8	9.6	23.1
Fla. kaolin	17.7	26.0	32.8	23.2	20.9
N. C. kaolin	17.9	26.3	33.1	28.4	21.1
SiO ₂	42.8	27.1	13.7	27.3	23.5
Ferric oxalate*	11.3	11.0	10.7	16.5	11.2



Reduction firings to cone 5, using the clay bodies mentioned above, produced the following results: Body A had a dark red, smooth, glossy glaze with patches of green. Body B had a light brown glaze with gray-green spots, and a glossy finish. Calcium and magnesium carbonate, added to the body, changed the color to a greenish-brown. Body C had a matte brown glaze, and an eggshell texture. Body D, high in iron oxide, had a glossy, dark brown glaze. Magnesium carbonate, added to the body, produced a matte finish. Body E had a light brown glaze with gray-green spots, and a glossy finish. Magnesium carbonate, added to the body, formed a green-brown glaze.²⁸

²⁷R. K. Hursh and E. C. Clemens, "Effects of Body Composition and Firing Treatment on Salt Glazes," American Ceramic Society Journal, 1931, 14:483.

²⁸Ibid., pp. 482-489.

Résumé of Technical Studies of Salt Glazing, by H. D. Foster (1941), called attention to salt-glazing temperatures and clay body requirements. Salt glazing will occur at temperatures of 2021^o, 2192^o, and 2372^o Fahrenheit (between cone 03 and cone 10) using clay bodies with alumina-silica ratios ranging from one part alumina to 3.3 parts silica to one part alumina to 12.6 parts silica. To form a glaze, the temperature must be high enough (2021^o to 2372^o F) to prevent the condensation of sodium vapor until it can combine with the silica of the clay body.

Foster stated that the holes on the surface (orange-peel effect) are the result of exploded gas bubbles on the surface. The raised portion of the glaze will settle and congeal to a wrinkled surface. It is believed that the gas was carbon monoxide which originated from amorphous carbon deposited in the pores of the clay body before the start of the salting process.²⁹

H. G. Schurecht's article, Salt Glazing of Ceramic Ware (1942), presented techniques of salt glazing for the ceramic artist. He maintained that temperatures of 2300 to 2400 degrees Fahrenheit (about cone 8 to cone 12) were needed for stoneware clays and fire clays which had an alumina-silica ratio of one part alumina to 4.6 to 12.5 parts silica. For best results, the ware was fire flashed in a reducing atmosphere prior to salting. The clay takes a better glaze by the reducing action of the kiln gases which converts ferric iron compounds to the ferrous state. (Schurecht does not explain why the glaze is improved, but a reducing atmosphere will yield a smoother, more lustrous surface than an oxidizing atmosphere.)

²⁹H. D. Foster, "Résumé of Technical Studies of Salt Glazing," American Ceramic Society Bulletin, 1941-1942, 20-21:239-241.

Salt glazing was done in a downdraft kiln and colors were formed as follows: Upon completion of the salting, the glaze was gray because the iron compounds were in the black ferrous state. By cooling the kiln in an oxidizing atmosphere, the ferrous compounds are converted into the reddish-brown ferric form.

Wood, or oil, was sometimes added to the salt to increase the temperature and to provide the needed water during salting.

Color effects were dependent on the amount of iron oxide in the clay body. White to tan colors resulted from bodies containing zero to two percent iron oxide and the color deepened to mahogany hues with a 4.75 to 8.2 percent iron oxide content. Blue glazes were produced on iron-free bodies by adding cobalt chloride to the salt.

Schurecht's research with slip-covered ware to achieve varied colors and borax additives to the salt to lower the salting temperature substantiate earlier findings.³⁰

Harold Driscoll (1950) enumerated salt-glazing techniques, kilns used in salt glazing, and a philosophy on salt glazing.

Semi-refractory plastic clays with an excess of free silica produced the desired effects in salt glazing. No glaze was applied to the ware, and only one firing was necessary. Pyrometric cones were of no use in determining temperature because of the chemical attack on the cones. He suggested the use of pyrometers for temperature control, or estimating the temperature by viewing the color of the ware chamber. (The disadvantage of a pyrometer is

³⁰ H. G. Schurecht, "Salt Glazing of Ceramic Ware," American Ceramic Society Bulletin, 1943, 22:45-46.

that maturing temperatures cannot be determined accurately because the combined factors of time and temperature are not indicated. Additionally the pyrometric thermocouple is damaged by acid after repeated use and is expensive to replace. Experience in this investigation has shown that cones, which indicate temperature over a time period, were adequate for temperature indication until the salt process commenced.) Firing should be carried to cone 9 temperature (2336° F) before salting is begun, then small amounts of salt should be introduced into the kiln, at intervals to allow the temperature to rise before the subsequent salting. Reduction should begin at about cone 010 temperature (1641° F) for best color development.

Kilns for salt glazing should be of downdraft design for efficiency. Kilns, and kiln furniture, constructed of graphitic high-carbon refractories are the most durable. Ware should be set open, never in saggars, to allow the flames free access to the ware. Graphite can be brushed on the kiln shelves to prevent ware and shelves from fusing together.³¹

Glazes for stoneware will be more artistic if they closely parallel the stony nature of the body. Salt glazing is essentially a simple process and the finished work should reflect the "...simplicity and honesty inherent in the method itself."³²

Höhr-Grenzhausen salt-glazed pottery procedures, using tunnel kilns, were described by Angelo Garzio (1963). Salt glazing was done by introducing salt into the top of the kiln through holes which serve as flues as well as

³¹Harold Driscoll, "Salt Glaze Firing," Ceramic Age, Oct., 1950, pp. 66-68.

³²Ibid., p. 68.

salt ports. During the firing, draw rings were withdrawn from the kiln to determine the clay density and reduction reactions. Oxidizing and reducing atmospheres inside the kiln chamber were present and produced gray color effects ranging from gray in the reducing atmosphere to orange-yellow on ware which received no reduction.

The use of metallic oxides combined with basalt as slips, which produce pale yellow and brown colors, was described. Photographs of Garzio's salt-glazed ware were included.³³

Kilns

Written material on catenary arch kilns is limited; however, general discussions of kilns and kiln construction are available in most ceramic textbooks.

In his booklet, Kiln Construction, Paul Soldner (1965) described the construction of a catenary arch kiln. He stated that the catenary arch kiln has several advantages: a self-supporting side and roof, a curved roof which guides the flame's path through the chamber to the flue more effectively than a standard arch, versatility in fuels used, and is less expensive to build than other kilns.³⁴

According to Daniel Rhodes, there are three essential elements of a kiln: the fire box, the chamber, and the flue. In his book, Stoneware and Porcelain, Rhodes (1959) classified kilns as updraft and downdraft, muffle,

³³Garzio, op. cit., pp. 20-22.

³⁴Paul Soldner, Kiln Construction, 1965, pp. 18-21.

electric, and salt glaze. He cited their advantages and disadvantages, and outlined firing procedures, kiln building materials and construction methods.³⁵

In A Potter's Book, Bernard Leach (1940) described English, Japanese, Korean, and Chinese kilns. Methods of stacking, firing, and cooling the kiln were outlined. Kilns which have been used for salt glazing were useless for other types of glazing because salt reacts violently with stoneware glazes and causes crawling and crinkling. (It must be mentioned that Leach was citing a general rule; however, a stoneware glaze which might react successfully with salt glazing will give different color and textural effects than when fired ordinarily. See Plate VI.) About one pound of salt per cubic foot of chamber space was introduced into the kiln through the fire box. Kiln furniture should be as silica-free as possible and high in alumina content.³⁶

The most valuable source of information on kiln design and construction techniques was obtained by personal contact with Angelo Garzio (1964), Associate Professor of Art, Kansas State University, while assisting him in building a rectangular-shaped, downdraft kiln of insulation fire brick for cone 7 to 14 glaze firing. The kiln was built on a hard fire brick platform which served as a foundation and floor; two thicknesses of insulation fire brick formed the straight mortarless walls; the roof consisted of a series of brick slabs standing on end supported by one-inch steel rods threaded

³⁵Daniel Rhodes, Stoneware & Porcelain The Art of High-Fired Pottery, 1959, pp. 194-206.

³⁶Bernard Leach, A Potter's Book, 1940, pp. 178-213.

through the bricks; four burner ports were located at the base of the side walls; the flue extended from the back wall base through a damper opening to the chimney. The door was laid up in the same manner as the walls. The kiln was fired with natural gas using four Ransome burners. The advantages inherent to the kiln were that the insulation was integrated with the structure allowing for minimum heat loss, and that the kiln was built quickly and could be modified easily because of its simple design and mortarless construction.

MATERIAL AND METHODS

Construction of Catenary Arch Kiln

Materials and Tools. For this study, a three and one-half cubic foot catenary arch, downdraft kiln was constructed with locally procured materials and firing ware made in the studio as class projects. The inside-chamber dimensions were thirty inches high, twenty-two inches wide at the base, and twenty-one inches deep. The arch, chimney, floor, and ends of the kiln were built of fire brick designed to tolerate heat of 2300 to 2400 degrees Fahrenheit. The outside walls, which incased the vermiculite insulation, were made of common construction bricks. Fire clay mortar was used between the fire bricks; stoneware slip was used between the outside wall bricks. The fuel tank, pipe, valves, and high-pressure hoses were procured from a local gas company. The burners used were atmospheric devices, one and one-half inch diameter, distributed by the Flynn Burner Corporation, New Rochelle, New York. The tools used were a cement trowel, hammer, framing square, level,

and buckets to hold the mortar and sand.

Construction Procedure. The kiln foundation consisted of common bricks laid horizontally level in a six-inch bed of sand. On top of the foundation, two courses of fire brick were laid flat for the kiln floor and base. A wooden frame, with plywood ends cut to the shape of the catenary arch and connected by slats thirty-six inches long, was built as a form. The slats were spaced close together to allow proper positioning of the bricks as the arch walls were being constructed. The wooden frame was placed on the kiln base, and the arch side walls were built. Since regular sized fire bricks (9" x 4½" x 2½") were used, varying amounts of mortar had to be used between the courses to form the desired arch. Filler of common, fine-grained river sand was added to the mortar to augment body and give a better fit. Four openings, two on each side, two and one-half inches by two and one-half inches, were made at the bottom of the arch wall for the burner ports (Plate I, Fig. 1). The bricks were laid up horizontally, staggering the courses. To provide for the sharp curve at the upper portion of the arch, one course of bricks on each side was cut lengthwise to form an arch, similar to a number three arch brick (9" x 4½" x 2½" x 1½") (Plate I, Fig. 2). The final courses consisted of normal-sized bricks. The keystone bricks were fire bricks cut wedge-shaped (Plate II, Fig. 2), and set the length of the kiln leaving a two and one-half inch opening for a salt port. After the mortar dried, the wooden frame was disassembled and removed, leaving the arch to stand freely (Plate II, Fig. 1).

After the wooden frame was removed, the back wall and chimney were constructed. The flue opening was four and one-half inches wide, the width of one brick, and five inches high, the height of two courses of bricks. A

EXPLANATION OF PLATE I

Fig. 1. Templates with connecting slats support walls during construction. Burner ports seen at base of kiln walls.

Fig. 2. Arch bricks compensate for sharp curve.

PLATE I



Fig. 1



Fig. 2

EXPLANATION OF PLATE II

Fig. 1. Frame removed after mortar sets.

Fig. 2. Wedge-shaped bricks form keystones.

One wedge brick omitted for salt port.

PLATE II



Fig. 1



Fig. 2

slot at the base of the chimney was provided and was designed to receive a free-sliding damper made from a portion of a used, silicon carbide kiln shelf (Plate III, Figs. 1 and 2).

Straight, common construction brick walls were built around the sides of the arch to hold the vermiculite insulation; around the burner ports, fire brick was used. The outer walls, four inches higher than the top of the arch, allowed for at least a two-inch thickness of vermiculite insulation above the kiln arch. At the top of the kiln, bricks were placed around the salt port to prevent the vermiculite from falling into the kiln chamber. Used pieces of asbestos sheets and corrugated roofing tin were utilized to cover the kiln top.

The kiln chamber was made smooth by a coating of fire clay slip.

Ten feet behind the kiln a one-hundred-gallon propane tank was placed. Extending underground was a pipe which led to two outlet-control valves and two hose connections, two feet from the kiln chimney. Two, three-quarter inch composition rubber, high-pressure hoses, one to each side of the kiln, were attached to the outlets. This order gave flexibility to the burner arrangement so that the burners could be placed in any of the four burner ports, or at the front of the kiln. The usual arrangement however, was one burner on each side of the kiln.

Maintenance and Exposure Problems. Exposure to the elements produced several problems. During the non-use periods, the kiln was covered with a tarpaulin; however, this did not prevent moisture from entering the mortar and bricks. Depending on the weather and time period between firings, drying was accomplished by pre-heating an empty kiln for at least four hours. During the winter months, the kiln seldom dried out short of a

EXPLANATION OF PLATE III

Fig. 1. Flue opening--four and one-half inches wide, five and one-half inches high.

Fig. 2. Slot at chimney base to receive free-sliding damper.

PLATE III

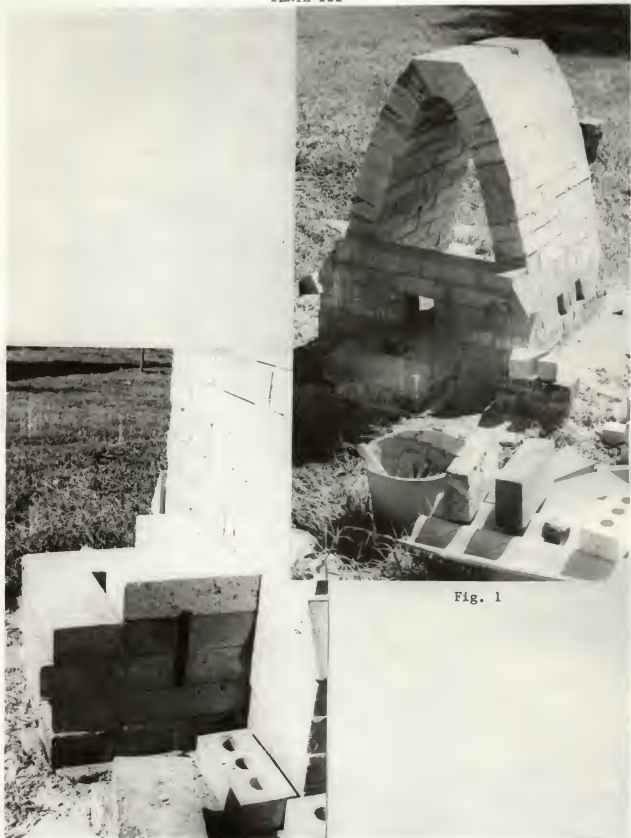


Fig. 1

Fig. 2

complete firing cycle. Weather and moisture had no deforming effects on the kiln structure. Although the moisture caused the outer-wall mortar to soften, no damage resulted.

The principle maintenance problem, during the early firings, was the accumulation of non-volatilized salt on the kiln floor and shelves. This problem was corrected by heavier applications of aluminum hydroxide kiln wash, reduction of the amount of salt per salting, thus, an increase in the number of saltings, and by extension of the firing period after the final salting. Expansion and contraction presented no problems in cracking or warping of the arch; however, the outer walls were affected. An angle iron and rod frame, placed along the front side and top of the kiln, prevented the common brick walls from breaking away from the kiln arch at the front end. A similar frame was not placed at the rear because it did not appear necessary during this series of firings, but with continued firings, it may be needed. To preclude the back wall and chimney from breaking away, an iron brace was placed against the chimney wall. This brace proved to be adequate.

Paul Soldner, in building his own kilns, has solved several maintenance and exposure problems encountered by this writer. Soldner provided kiln insulation by adding successive layers of brick over the first layer (the number of layers of bricks is dependent on the kiln size). This procedure eliminates the need for a straight wall to hold vermiculite insulation material, and the aesthetic qualities of a catenary arch are retained. Cement mortar was used between the outside-wall bricks to protect the kiln

against inclement weather.³⁷

Unless silicon carbide shelves are protected with a heavy coating of aluminum hydroxide kiln wash, the shelves become extremely pitted and weak. During this investigation, one shelf collapsed which was not protected with aluminum hydroxide. After close inspection of the shelf, it was determined that the shelf was so severely pitted it could not support the weight of the ware. In some cases, the insulation fire bricks were deformed if not protected from the salt vapors by kiln wash or fire clay slip.

Operational Procedures

Stacking Procedures. Because several potters disagree on the method of stacking a salt-glaze kiln, careful observations were made in this area. Little concern was given to ware arrangement in the first firing, which was a bisque firing; however, shelf placement was considered for proper heat circulation (Plate IV, Fig. 1). The second firing was a cone 7 (2264° F) glaze firing and close stacking was employed (Plate IV, Fig. 2). During subsequent salt-glaze firings, best results were achieved by placing the ware at least one-half inch apart (Plate V, Fig. 1). No glazing, to spotty glazing, occurred on pots placed closer than one-half inch. More space, at least two inches, is needed between the top of the ware and the shelf above in salt-glaze firing than in other studio firings to allow the gases to come in contact with the entire ware surface. This spacing was especially

³⁷Paul Soldner, "Workshop: A Kiln is Built," Craft Horizons, 1965, 25:39.

EXPLANATION OF PLATE IV

- Fig. 1. Bisque firing: Angelo Garzio places cones in kiln. Shelves arranged to allow flames to flow between walls and shelves. Tight stacking.
- Fig. 2. Cone 7 common-glaze firing: Ware stacked closely.

PLATE IV



Fig. 1



Fig. 2

EXPLANATION OF PLATE V

The bottom shelf was placed on the baffle walls and other shelves were supported with split bricks laid on edge or soap bricks placed on end.

Fig. 1. After several salt-glaze firings, pots were set at least one-half inch apart and a space was left between top of ware and shelf above to allow salt vapors to move around and into the ware.

Fig. 2. The size and type of ware being fired determined height of shelves. (Note: View of kiln after a salt-glaze firing.)

PLATE V



Fig. 1



Fig. 2

helpful when firing bowls or other open containers. When the salt was introduced through the salt port, in the kiln crown, open vessels on the top shelf and on the outer edges of the lower shelves were filled with non-volatilized salt. To defuse the salt downward toward the burner ports, a semi-circular clay form was constructed and placed directly under the salt port.

Several experiments were made to prevent the ware from fusing to the floor and kiln shelves. Coarse sand, placed under the ware, was partially satisfactory but in areas of non-volatilized concentrations, the ware fused to the shelves. Tripods were successful. Stoneware rings, made by slicing a clay cylinder while in the leather hard state, dipped in aluminum hydroxide, and placed under the ware, prevented the ware from adhering to the shelves. These stoneware rings proved most effective and gave better support to the ware than the tripods.

Saggers were found to be unsuccessful for salt glazing in this kiln because they required too much space, and the saggers in the lower part of the kiln, next to the burner ports, would deform, causing the saggers above to fall or touch the side of the kiln.

Fuel. Propane proved to be a satisfactory fuel for firing ware in the kiln; however, it was more expensive than natural gas. The price of propane was thirteen cents per gallon. A maximum of three firings was obtained from one one-hundred gallon tank of propane; the average number of firings, depending on climatic temperature and periods of non-use, was two. More efficient use of propane could be expected if a larger kiln were used, allowing better circulation of gases within the kiln, and if the kiln were not allowed to cool after each firing.

Burners. Using a trial-and-error method, several burner arrangements with LR-2 Fieser inspirator burners were tried. Two burners with orifice sizes from 57/100 to 60/100 inch, which produced approximately 18,000 BTU's per burner and rotated among the burner ports, gave the best results.³⁸ Other orifice sizes would not give a satisfactory flame. Larger orifices produced only reducing flames, and smaller orifices prevented the entry of sufficient fuel through the burner. During two firings, four LR-2 Fieser burners were tried; however, the results were not significantly better than the results with two burners and the procedure was discontinued.

Primary air was introduced in the normal manner by adjusting the primary air valve on the burner. After the kiln became slightly red inside, the primary air valve was placed on full-open and kept in that position throughout the remainder of the firing cycle.

The best secondary air mixture was achieved by placing the nozzle of the burner one to two inches from the outside of the burner port.

Baffle Walls. In all salt firings, fire bricks or split fire bricks (fire brick cut longitudinally, 9" x 4½" x 1½") were used for baffle walls. To save space, the most effective baffle wall was two split bricks laid on edge lengthwise. The wall height could then be determined by stacking additional bricks on top of the first row of bricks. The lower shelf was positioned on top of the baffle wall. To allow for an adequate passage of heat through the kiln, a space was left between the wall and the shelf by using small pieces of old kiln shelves placed under each shelf corner.

³⁸The burner BTU output was obtained from the Tri-County Rural Gas Company, Manhattan, Kansas.

It was determined that the baffle wall must be close to the rear of the kiln (no closer than one-half inch) to prevent the flames from reaching the flue before they could be forced upward to carry heat to the upper portion of the kiln. The size and type of ware being fired determined the height of the top shelf (Plate V, Fig. 2). Either split brick laid on edge, which extended the height of the baffle wall, or soap brick (fire brick cut longitudinally, 9" x 2½" x 2½") placed on end supported the upper shelf. There seemed to be no significant difference in the reaction inside the kiln with the two procedures. A three-inch space between the kiln wall and the baffle wall forming the fire box was adequate.

Temperature Control. The problem of even heat distribution was extremely difficult to solve and several modifications were made in the kiln. Initially, cone 7 (2264° F) temperature could not be reached and because the kiln would not oxidize, it was believed that insufficient draft was the cause. After making an additional flue opening at the top of the kiln, which allowed twice the amount of draft, the heat problem was not solved. It was concluded that the burner orifice size was too large. After correcting the burner orifice size from 35/100 inch to between 57/100 and 60/100 inch, the burner would give an oxidizing flame in the kiln. Since the draft was difficult to control through the flue opening at the top of the kiln, the flue was closed and not used again. By manipulating the damper, the fire could be controlled from an oxidizing atmosphere to a reducing atmosphere.

The top of the kiln was consistently cool. Clayton Bailey suggested making an opening at the top of the kiln.³⁹ Since the added flue at the

³⁹ Clayton Bailey, letter to writer, 26 June 1965.

kiln top had already produced unsatisfactory results, an alternate procedure was followed. As soon as the kiln reached red heat, the salt port was opened which allowed the upper portion of the kiln chamber to reach temperatures between cone 3 (2134° F) and cone 4 (2167° F). Nevertheless, the only way the upper chamber would reach cone 7 temperature was to place a burner through an opening in the door (the upper spy hole) for short periods of time.

The inability to achieve an even temperature throughout the kiln was attributed to two factors. Soldner suggested that the kiln was too small for necessary circulation of flames and salt vapor.⁴⁰ MacKenzie suggested that the kiln might be too high.⁴¹ Because the kiln was one and one-third times higher than the width of the kiln at the base, the flames did not reach the top. The flames could not be deflected to the kiln top by increasing the baffle wall height.

During temperature control experiments it was found that the ware being fired was successfully salt glazed at temperatures between cone 3 and cone 8 (2305° F), although temperatures above cone 6 (2232° F) gave slightly better results.

Chimney. Originally, the chimney was built only to the top of the kiln. Since this height did not allow adequate draft, eighteen inches of loose bricks were stacked above the chimney. Sufficient draft was then provided and no other chimney arrangement was devised.

Type of Door. The door was made by stacking bricks in the open end of

⁴⁰ Paul Soldner, letter to writer, 19 July 1965.

⁴¹ Warren MacKenzie, letter to writer, 28 June 1965.

the kiln but leaving openings for spy holes. To compensate for the rectangular form of the brick and the arch curve, pieces of insulation fire brick were cut into triangular shapes to fill the small openings between the door bricks and kiln wall. Placing the bricks lengthwise, one-half inside and one-half outside, proved to be the best arrangement. Several soap bricks were used in series where spy holes were desired. To make the door tight, clay was placed in the seams between the bricks, though after several firings, this practice was discontinued and no significant changes resulted. The disadvantage of this loose brick construction was the excessive time involved in laying up the door.

Draw Trials. Draw trials, on aluminum hydroxide pads, were made with small pieces of clay, and were placed on kiln shelves directly inside the spy holes and on the kiln floor in the burner port, but out of the flame's path.

A draw trial was pulled out with a heavy wire to determine glaze effects following each pound of salt thrown into the kiln.

Firing Schedule. After thirteen salt-glaze firings, the following firing schedule gave best results.

- A. Pre-heat stacked kiln for two to four hours with damper and spy holes open. During winter or after long periods of non-use (two weeks or more), kiln should be pre-heated before ware is placed inside.
- B. Firing:
 1. Have burners on low with oxidizing flame for one hour.
 2. Increase burner output at fifteen to thirty minute intervals until burners are on full with oxidizing flame. Damper should

be full-open during this period.

3. When fire boxes reach red heat and a slight red glow is seen through spy holes, close damper to one-half open.
4. When kiln becomes bright red inside, begin reduction to desired degree. Damper should be manipulated from one-half to one-fourth open.
5. Open salt port to allow heat to rise to top of kiln.
6. Continue to adjust reduction to desired degree.
7. When ware matures, commence salting. At intervals, introduce one-half pound crystalline salt into kiln through burner ports in small paper bags, or pour salt into salt port. Alternate burners among ports to insure complete salt volatilization. Close damper during saltings; open one-fourth between saltings. Wait five to ten minutes for temperature to rise before adding another one-half pound salt. Maintain moderate reduction. Pull draw trials after each pound of salt.
8. After last salting, continue firing five to ten minutes for complete salt volatilization.
9. Turn burners off. Immediately close damper and burner ports.

ANALYSIS OF FIRED WARE

Clay Body

One clay body containing twenty-eight percent alumina and fifty-seven percent silica was used for all salt-glaze experiments.

The following analysis shows the percentage by weight of compounds contained in the clay body (table 5).

Table 5. Clay body composition.⁴²

Compound	:	Per cent
Alumina		28.50
Ferric oxide		1.23
Titania		1.98
Magnesia		0.22
Lime		0.08
Alkalies		1.18
Sulphur		0.24
Loss of ignition		9.39
Silica		57.32

Although the ratio of one part alumina to three to twelve parts silica, as suggested by Foster and Schurecht as necessary for a salt-glaze formation, was not met, the clay body used produced satisfactory salt glazes.⁴³ Colors produced with this clay body, without colorants, ranged from light gray to tan. Ware with one to three percent ferric oxide added to the body glazed to a dark brown hue.

Colorants

Black slip, over the body, produced dark brown hues with spots of deep

⁴² Lowell H. Brown, 8310 Riggs Road, Overland Park, Kansas.

⁴³ Foster, "Résumé of Technical Studies of Salt Glazing," p. 239; Schurecht, "Salt Glazing of Ceramic Ware," p. 46.

brown to maroon. Albany slip, with ten to twenty percent ferric oxide, used on the inside of covered jars and closed forms, was successful and produced shades of brown. The color range did not vary significantly with different amounts of added ferric oxide. Decorative patterns of Albany slip, on the outside of ware, fired brown. A salt glaze was achieved over white slip when the slip melted and when coloring oxides and fluxes were added to the slip. By adding fifteen percent borax, two percent chromium oxide, two percent cobalt carbonate, and six percent nickel oxide to white slip and applying a thin coat to the ware, handsome polychrome effects resulted. However, slip applied heavily caused excessive blistering and hues of blackish-green to black.

Investigations were made with three slip combinations using the clay body and coloring oxides. The color achieved by adding four percent rutile and one to two percent cobalt carbonate was bluish-black. Five and one-half percent nickel oxide with the clay body slip gave a uniform bluish-gray hue. The clay body slip with seven percent rutile gave an unattractive brownish-black color. It was found that the clay body slips did not mature in a cone 7 (2264° F) firing, that they did not accept the salt, and that excessive crawling resulted. The addition of flux to the clay body slip might have corrected these defects.

Stains gave satisfactory color combinations. Copper sulfate, sprayed thickly on the raw ware or bisque ware, produced a subtle deep grayish-green. Heavy coats of cobalt carbonate sprayed on the ware, produced a brilliant blue. Ferric oxide, brushed on in decorative patterns, produced handsome browns. Efforts with chromium oxide failed because the chromium oxide did not mature and the result was a flat, intense green.

Salt Mixtures

In an effort to substantiate Everhart's findings of producing a salt glaze by adding salt to slip, various amounts of salt ranging from fifteen to thirty percent were added to clay body slip.⁴⁴ However, these experiments did not produce a glaze and a dark gray color resulted.

An experiment using eight pounds of salt with ten percent borax (12.8 oz.) produced a thick uniform gray glaze, and the applied slip and stain decorations were not visible. It was concluded that less salt should be used in the salting process when borax is added. The correct amount of borax could not be determined in the limited number of trials.

Interesting colors were achieved by adding varying amounts of coloring oxides to the salt. By adding one to two percent ferric oxide to the salt, rich browns and maroon resulted. Three percent cobalt carbonate and three percent chromium oxide, with the salt, produced spots of rich blue-green. No significant change was noted in glaze effects between salt used alone and salt with two percent nickel oxide added. Perhaps more nickel oxide or nickel oxide with another colorant would give a diversity to color effects. Attempting varied effects by using small amounts of wood chips, saw dust, and oil, with the salt, did not produce any change from salt used alone. The advantage of granulated salt over rock salt was that granulated salt volatilized slightly faster, and it was easier to introduce into the kiln. The exploding granules of rock salt flew out of the kiln causing a safety hazard.

⁴⁴Everhart, op. cit., p. 401.

The amount of salt caused some change in color on the ware. Usually, three to four pounds of salt produced an attractive, orange-peel textured finish with gray to tan color. Yet, exciting dull browns and reds were produced with one pound of salt. Increasing the amount of salt to ten pounds gave sparse polychrome effects with a hard, glossy, mottled surface.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Plausibility of the Catenary Arch Kiln for Salt Glazing. The results of this investigation indicate that the catenary arch kiln is well suited for salt glazing. The height of the kiln for this experiment was too great in relation to its width. The basic design of the catenary arch can be altered to compensate for this design fault. Since the catenary arch is formed by a chain suspended from two points, flexibility is provided for any desired height-width ratio, but the height must not exceed the width at the base of the kiln.

Fuel. Although propane fuel was used for this experiment, any natural fuel may be used. The only restriction on fuel is its cost and availability.

Operation. For even salt glazing on all ware, one-half inch space or more was needed between ware. Open bowls were glazed inside when a two-inch space or more was left between the top of pottery and the shelf above.

Baffle walls were necessary to form a fire box and to diffuse the flame evenly throughout the kiln. To conserve space, shelves were placed on top of the baffle walls.

Materials. High quality materials must be used if the kiln is expected to be operated over long periods of time. Because the insulation fire bricks were deformed by the salt vapors, the bricks were coated with kiln wash or slip. Kiln furniture, particularly silicon carbide shelves, must be protected from the salt vapor with a thick aluminum hydroxide coating to prevent excessive pitting which ultimately weakens the shelves. To preclude deterioration, the kiln must be protected from natural elements.

Salt Glaze Results. A clay body with an alumina-silica ratio of one to two will produce a satisfactory gray to tan salt glaze at temperatures between cone 3 (2134° F) and cone 8 (2305° F), but with slightly better results at temperatures above cone 6 (2232° F). The same clay body used in slip form with coloring oxides added would not form a salt glaze.

By adding one to three percent coloring oxide to the salt, interesting color effects were achieved.

The amount of salt affects the color of the ware. Heavy applications of salt gave sparse, mottled polychrome glazes; very light applications gave attractive matte browns. One to one and one-quarter pounds of salt per cubic foot of kiln space gave the best surface texture and color results.

Volcanic ash and potassium feldspar glazes were combined with salt glazes successfully.

Recommendations

The following recommendations for the construction of a downdraft catenary arch kiln are offered as a result of the problems encountered during this investigation.

Height-Width Ratio. The height of the kiln should be no greater than the width at the base. It is believed that this height-width ratio will allow for adequate heat distribution in the kiln chamber. When determining the length of the kiln, consideration must be given to the number of burners to be used and their location because a long kiln will require additional burners to preclude cool spots.

Spy Holes. Sufficient small openings must be provided for spy holes to view cones and draw trials. During early firings of a new kiln, it is advantageous to observe the chamber atmosphere from all sides.

Material-Design Relationship. Brick sizes should be carefully considered when designing a kiln to eliminate unnecessary cutting and fitting during construction. For example: a kiln four feet (48") long would require cutting a brick in each course. The size of the kiln should be changed to forty-five inches long which would require five bricks in a course and no cutting would be needed.

EVALUATION OF THESIS POTTERY

Thirty-two pieces of pottery were selected from the salt-glazed experiments as a representation of work completed during this study. No attempt has been made to emphasize any particular philosophical approach to pottery as an art form, but it is believed that the pieces selected have artistic qualities and, if viewed with an aesthetic attitude, can be appreciated by the spectator. Admittedly, different observers may see different attributes of the work--all relevant to an aesthetic appreciation. Judgments of pottery cannot have a common denominator nor can they be mere expressions

of sentiment, but rather, they must be "informed, discriminating and unified."⁴⁵

The pottery pictured in Plates VI through XXIV manifest a simple, but honest, expression of the earthy, plastic quality of clay. There are limited color variations in this group, but individually, the pieces clearly demonstrate the directness of the salt-glaze process.

⁴⁵Jerome Stolnitz, Aesthetics and Philosophy of Art Criticism, 1960, p. 428.

EXPLANATION OF PLATE VI

Salt-Glazed Stoneware Closed Form

The closed form with speckled brown and red hues on one side and tan on the other, is a good example of the successful union of volcanic ash, high-fire glaze and salt glaze. Simple full swelling lines of the form are interrupted only by the finality of the folded lip ($7\frac{1}{2}$ " tall).

PLATE VI



EXPLANATION OF PLATE VII

Salt-Glazed Stoneware Covered Jars

Left. A gray-brown, salt-glazed, covered jar with a graceful circular design by application of wax resist and Albany slip create an intrinsic union between the decoration, the pulled handle and the roundness of the belly (7½" tall).

Right. The wax resist-Albany slip decoration of the covered jar is barely discernible under the gray-brown salt glaze sparsely speckled with orange hues (7" tall).

PLATE VII



EXPLANATION OF PLATE VIII

Salt-Glazed Stoneware Open Forms

The open forms have black and red slip poured over the leather hard clay.

Left. Incising through the slip decoration creates contrasting color relationships between the maroon and brown areas with the tan color of the clay body ($5\frac{1}{2}$ " tall).

Right. Brown and maroon hues with sparse spots of purple were caused by the red and black slip poured over the piece while it was still damp (5" tall).

PLATE VIII



EXPLANATION OF PLATE IX

Salt-Glazed Stoneware Forms

Left. The walls of this open form were indented with finger forming zig zag grooves while still damp on the wheel. The lip was formed by overlapping the clay. Albany slip, with twenty percent iron oxide added, and dropped on the pot with a brush, gave dark brown spots seen under the tan glaze. The lip and inside of the pot are covered with Albany slip (6" tall).

Right. The spontaneity of this small form demonstrates the plasticity of clay by raising a cylinder and forcing the upper part out and down, then pressing in the walls. The outside is reddish-brown; the inside is gray-green (4" tall).

PLATE IX

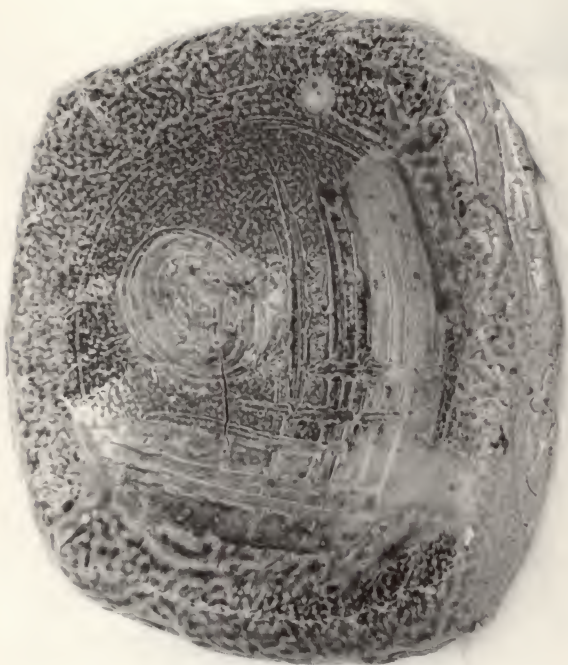


EXPLANATION OF PLATE X

Salt-Glazed Stoneware Slab Pot

Blue slip, with sgraffito marks, form the decorative pattern on the gray, green, and brown polychrome slab ash tray (6" wide).

PLATE X



EXPLANATION OF PLATE XI

Salt-Glazed Stoneware Jug and Cups

The surface striations through red slip on the cups give pleasing textural and color effects of gray and brownish-red. The inside orange-peel textured glaze is brown and gray (3" diameter).

Red and black slip was brushed over the jug. The incised lines along the wall of the rich brown colored jug was made with a saw blade. The bold handle springs from the shoulder just below the neck accenting the simple cylindrical form ($7\frac{1}{4}$ " tall).

PLATE XI



EXPLANATION OF PLATE XII

Salt-Glazed Stoneware Pitchers

Left. The outside of the pitcher is tan with sparsely speckled spots of brown slightly discernible over the entire body. The foot was formed by trimming away the rough clay after the pot was cut from the wheel. The handle flows freely from the form making a curve contrasting with the belly and attached near the foot (5" tall).

Right. Cobalt carbonate was sprayed over the pitcher which caused a mottled surface of intense blue over a background of light tan (7" tall).

PLATE XII



EXPLANATION OF PLATE XIII

Salt-Glazed Stoneware Bottle

The conventional bottle form with sharp contrast between the brown high spots and the gray low spots of the orange-peel textured surface illustrate forthright characteristics of the salt-glaze process (6" tall).

PLATE XIII



EXPLANATION OF PLATE XIV

Salt-Glazed Stoneware Jars

The simply fashioned forms were executed with considerable freedom, depressions and decoration express spontaneity, and the folded lips manifest the plasticity of the clay.

Left. The mottled brownish-red glaze resulted from iron oxide added to the salt during salting (7" tall).

Right. The gray and tan glaze is broken with dark tan and brown circular spots and linear brown areas (7½" tall).

PLATE XIV



EXPLANATION OF PLATE XV

Salt-Glazed Stoneware Bottle

The texture of the gray and brown pot was made by pressing the soft damp surface with a vegetable grater. Red slip brushed on in a circular pattern complements the roundness of the form (6½" tall).

PLATE XV



EXPLANATION OF PLATE XVI

Salt-Glazed Stoneware Free-Form Pot

The interrelationship of slab and thrown methods is complete in the free-form pot of subtle greens and purplish-black. The thrown, robust base supports an equally strong, subtly curved, slab body with natural finger marks and needle scratches. The attractive, deep green color was achieved by spraying copper sulfate on the pot before salt glazing (12" tall).

PLATE XVI



EXPLANATION OF PLATE XVII

Salt-Glazed Stoneware Bottle Forms

These bottle forms are conservative in concept of form and simply decorated with black slip splashed on with a brush.

Left. Matte tan with slip decoration (4" tall).

Center. Tan to dark gray (4" tall).

Right. Brown glaze with incised line decoration. Iron oxide added to salt during firing (4" tall).

PLATE XVII



EXPLANATION OF PLATE XVIII

Salt-Glazed Stoneware Covered Jar

The mottled brown and maroon hues with prominent orange-peel textured surface, throwing marks, and subtle swelling of the walls and lid unify the form into one entity (7½" tall).

PLATE XVIII



EXPLANATION OF PLATE XIX

Salt-Glazed Stoneware Bottle

The unembellished surface and rhythmical roundness of the small brown salt-glazed bottle form is simply stated as a single intrinsic unit ($5\frac{1}{2}$ " tall).

PLATE XIX



EXPLANATION OF PLATE XX

Salt-Glazed Stoneware Bowl Forms

Left. The orange-peel textured surface ranges in color from tan to brown with areas of gray. Dark brown spots were formed by red and black slip dabbed on with a brush. The refined curved walls of the pot make a transition at the shoulder into a reverse curve terminating at the smooth lip ($4\frac{1}{2}$ " tall).

Right. Black slip decorations of irregular patterns give an interesting contrast to the austerity of the almost straight walls and the precisely flared lip. The inside of the bowl is gray-green; the outside is tan and brown ($4\frac{1}{2}$ " tall).

PLATE XX



EXPLANATION OF PLATE XXI

Salt-Glazed Stoneware Bottles

Left. The foot of the bottle was formed by hitting the excess clay at the base with a small board after the form was cut from the wheel. Iron oxide was added to the salt causing a rich medium brown hue. Red slip applied to the raw pot colored the wall depressions dark brown (6" tall).

Center. An extremely thin glaze gave an uneven dull, but handsome, brown glaze. Iron oxide brushed on the neck formed a red-brown hue (5" tall).

Right. Iron oxide added to the salt gave a rich brown salt glaze and red and black slip decorations were splashed on with a brush (6½" tall).

PLATE XXI



EXPLANATION OF PLATE XXII

Salt-Glazed Stoneware Tea Pot

The tea pot, with reed handle, of gray and tan hues has brown speckles over most of the surface. The diameter of the trimmed foot, somewhat narrower than the lip, makes an exciting contrast with the fullness of the lower part of the belly. The pulled handle lugs, attached to the pot slightly above the center, extend upward and outward allowing for the convenient attachment of the reed handle (9" tall with handle).

PLATE XXII




EXPLANATION OF PLATE XXIII

Salt-Glazed Stoneware Closed Form

The handsome speckled green glaze with sparse spots of black enhance the low rounded form (4" tall).

PLATE XXIII





EXPLANATION OF PLATE XXIV

Salt-Glazed Stoneware Vase

The vase form, with a lip, formed by overlapping the clay, and paddled foot, was splashed with black and red slip which caused the dark brown spots on the tan-brown, orange-peel textured glaze. The inside and the lip were glazed with Albany slip (5½" tall).

PLATE XXIV



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SALT GLAZING IN A CATENARY ARCH KILN

by

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The purpose of this study was to determine the plausibility of salt glazing in a downdraft, catenary arch kiln.

Sources for this study included references to historical and technical research in salt glazing and kiln construction, and personal correspondence with potters who have salt glazed, and personal experience.

A three and one-half cubic foot, downdraft, catenary arch kiln was built with emphasis on construction methods and operational procedures for the experiments. One clay body, with slips, stains, and coloring oxides in the salt for color effects, was used.

The results of this investigation indicated that the catenary arch kiln was well suited for salt glazing, and can be built with a limited number of tools, fired with a variety of fuels, and constructed with locally procured materials, except the burners. The most serious maintenance problem was care of the kiln furniture, but aluminum hydroxide and/or other non-silica refractory material, abundantly applied, sufficiently protected the silicon carbide shelves from excessive pitting by the action of the salt vapors.

Even salt glazing resulted on ware set one-half inch apart and on open forms set leaving two inches of space from the shelf above.

For temperature control, baffle walls were necessary to direct the flame upward and around the ware within the kiln chamber. The height of the kiln arch should not be greater than the width at the base, otherwise the upper portion of the kiln chamber will be cool.

A clay body with one part alumina to two parts silica produced gray, brown, and tan salt glazes at temperatures from cone 3 (2134° F) to cone 8 (2305° F). The clay body used as slip decoration combined with coloring

oxides would not mature at cone 7 (2264^o F). The addition of a flux to the clay body slip might have corrected this defect.

Copper sulfate stain sprayed on raw or bisque ware produced deep subtle green; iron oxide stain produced handsome browns. Three percent cobalt carbonate and three percent chromium oxide added to the salt produced spots of rich blue-green.

Photographs of thirty-two pieces of salt-glazed ware were included as a representation of the work completed during the study.