1980

An exploration of caustic soda textile design effects on cotton

June Marie Bissell
Iowa State University

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An exploration of caustic soda textile
design effects on cotton

by

June Marie Bissell

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF ARTS

Department: Art and Design
Major: Art and Design (Craft Design)

Signatures have been redacted for privacy

Iowa State University
Ames, Iowa

1980

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GLOSSARY

acrylic polymer gloss medium: a plastic solution which dries to form a shiny insoluble surface.

alkali: the opposite of acidity. Alkaline materials neutralize acids. A strong alkali will dissolve animal fibers.

airbrush printing: a mechanical process by which a fine spray of color is blown onto a fabric.

buckram: a plain-weave, coarse, open fabric.

canning: a hand-printing process performed with a juice can which has had top and bottom removed. Printing paste is put in the can which is subsequently scraped across the fabric, leaving a thin film of color.

caustic soda: one of the most important alkalies and widely used in textile processes.

cheesecloth: a lightweight, thin, loosely woven, carded cotton cloth made in a plain weave.

color xerox printing: using a special paper, the printed design is pressed against the fabric. Application of heat and pressure transfers the design to the fabric and the color is set.

disperse dyes: any of a number of insoluble dyestuffs dispersed or held in suspension in the dyebath and in this suspended form they are absorbed by the fibers.

dye receptivity: the ability of a textile fiber to absorb dye.

fiber reactive dye: dyestuff which reacts chemically with cellulose fibers under alkaline conditions.

gelatin: a semi-solid, apparently homogeneous, substance that may be elastic and jellylike.

gum arabic: one of a class of colloidal substances which are exuded by or extracted from plants, and are gelatinous when moist and hard when dry.
hand: a quality or characteristic of fabrics perceived by sense of touch.

hydrometer: an instrument used to measure density, i.e., specific gravity of liquids. It consists of a weighted, narrow, glass cylinder or tube, the stem of which carries a scale. According to the density of the liquid under test the hydrometer will float at a definite position in the liquid enabling a numerical reading to be taken from the graduated stem against the surface level of the liquid.

mock voile: fabric resembling voile, a lightweight sheer fabric with a crisp, wiry hand. See "parchmentized."

mylar: a polyester film which retains its physical and electrical properties under a wide range of heat and humidity changes, and has a good resistance to attack by chemicals.

parchmentized: cotton fabric which has undergone a finishing process to give cotton fabrics a variety of effects such as transparency, linen-like hand, and texture. Also known as mock voile.

specific gravity: the ratio of the weight of any volume of a substance to the weight of an equal volume of distilled water at 4°C.

spinnaker cloth: a strong, lightweight, airtight nylon fabric used in sailmaking because of its capacity to hold air.

sulphuric acid: a dibasic oil, liquid which is clear, colorless, odorless. It is highly corrosive in action.

twaddle: named after William Twaddell, Scottish inventor. A unit used in measuring liquids heavier than water.
INTRODUCTION

Fiber and fabric, materials formerly associated with household arts, are now used to create exhibition quality artworks. Wall hangings, garments, quilts, and soft sculpture are the most common vehicles for expression in these media. Artists and designers, however, have not limited themselves to these vehicles for artistic expression. Fabric can now play a major role in choreography or "performance art." Textile inflatables and wind sculpture utilize the capacity of some fabrics to retain a particular shape when filled with air. Architectural forms, such as tensile fabric structures, canopies, and awnings utilize textile qualities of stretch, limited weight, translucence, and water repellency. Fabric and fiber artists are also called upon to create theatrical backdrops and monumental banners which add color and interest to large spatial areas indoors and out.

Traditionally, fabrics made of natural fibers have been the only materials available to artists. Commonly used techniques include batik, tie-dye, block and screen printing, stitchery, and applique. Contemporary artists have shown a preference for these materials and techniques for various reasons. With them, an artist can produce a wide variety of desired effects without requiring elaborate facilities and equipment. Before World War II, most of the man-made fabrics now available did not exist. Until recently dyes, important to the textile artist, were only effective on natural fibers. Lastly, instructional literature has been written about traditional materials and techniques. Educational literature concerning new technology in art fabric techniques is scarce.

Professional journals keep individuals in the textile industry informed of contemporary developments in industrial textile materials and processes. Much of this information could be of educational value to the nonindustrial textile artist as well, but because the journals are
written in technical professional language, they are not easily understood by artists who may not be familiar with scientific or industrial terminology.

Caustic soda (also known as NaOH, sodium hydroxide, "household lye"), which is used extensively in industrial cotton textile processing, can produce effects in fabric which have not been utilized by artists using textile media. Outside of commercial textile production, it has been used traditionally by the textile artist to dissolve indigo in preparation for natural dyeing. Thus, it is a familiar material to the dyer. When a strong solution of caustic soda is applied to loosely woven cotton fabric, it will shrink to approximately one-half its original surface area. Cotton treated with caustic soda will absorb more dye than untreated cotton in the same dyebath. Caustic soda's effects on cotton are different from those produced using other traditional materials. The author believes the application of caustic soda to cotton fibers holds potential for creating designs and fine artworks. Search of current literature reveals that procedures for creating caustic soda design effects on cotton do not appear in literature intended for artists. It is highly probable that the majority of artists working with textiles are unaware of the capabilities of caustic soda.

The objective of this study is to explore the uses of caustic soda for designing when using cotton. The author will develop methods whereby other textile artists may safely apply caustic soda to produce design effects on cotton. There will be five phases in the study: (1) the author will review literature concerning the history of caustic soda in the textile industry; (2) the author will develop studio/laboratory methods for testing caustic soda as a design medium; (3) the author will then conduct experiments to determine the simple and safe procedures an artist must follow for applying caustic soda in a studio environment;

1 The author has found only one such reference to caustic soda in art fabric journals. Kax Wilson, in the Fall 1979 issue of Interweave (Vol. 4, No. 4) discusses the commercial plisse process from the standpoint of origin. In her discussion, no mention is made of the potential of this technique for artists.
(4) an instruction manual for textile artists will be prepared which will discuss several varied design effects obtainable using caustic soda and recommend safe methods for handling caustic soda in the studio; and (5) the author will design and produce a body of artwork which will demonstrate design effects possible in textiles produced with the application of caustic soda on cotton.
Contemporary developments by science and industry have recently provided textile artists with a great variety of fabrics with which to work. One example is polyester fabric which can be produced to copy the appearance and hand of either cotton or silk. These two natural fibers, used widely by textile artists, are susceptible to decay caused by exposure to humans and the elements. Polyester fabrics do not deteriorate, and can be utilized well by artists concerned with the longevity of their works. However, until the mid-60's, when disperse dyes were perfected by the textile industry, it was difficult to dye polyester fabrics. Today, polyester and disperse dyes are used by an increasing number of artists. In the textile artist's studio, though lacking the sophistication of the textile industry, these dyes are being used with varying degrees of success, but their popularity seems to be increasing.

Nylon is another synthetic fiber used by artists today. Nylon spinnaker cloth was designed to replace cotton canvas in sailmaking. Noted for its tight weave, light weight, and weatherproof qualities, it has proven to be a successful material for artists who create outdoor banners and other works which are exposed to the elements. Environmental artist Otto Piene uses spinnaker nylon to create wind sculptures and inflatables of mammoth proportions which require group collaboration to become airborne.

Metallic and plastic fabrics and films have been developed for various end uses. One such material originally created for the space program is mylar, a shiny, silver, tissue-thin fabric. Practical qualities of these fabrics are that they may be wiped clean with a damp cloth, do not ravel, and may last indefinitely. Mylar and metallic-colored plastics have experienced increased use by artists in fiber and fabric media. Weaver Arturo Sandoval is known for his woven and printed mylar wall hangings. Metallic textile sculptures by Pricilla Sage
were chosen to hang in Olympic Village at the 1980 Winter Olympics held at Lake Placid.

The textile industry now provides artists with a wide selection of knit fabrics composed of varied fibers. One reason why knits may appear in fabric sculptures is that they may be stretched and stuffed without the puckers and gathers which occur when woven fabrics are used. Nylon stockings have become part of many soft sculptures. Because knit hosiery bears a close resemblance to the color and quality of human skin, it has been chosen as the raw material from which to create parts of dolls and sculptural human figures constructed by some textile artists. Aleksandra Kasuba combines 100-percent stretch nylon with a scientific knowledge of the dynamics of tension to create sculptures which derive their character from the way the flat planes of the fabric change when stretched over a three-dimensional armature.

An increased familiarity with advanced technology has enabled artists to utilize machines and processes not previously available. Photoscreen printing has been used by textile printing industry as well as textile artists for several decades. It has become an increasingly popular method for applying images to fabrics. An elaborate process is used to transfer the photographic image to the screen producing effective visual results. Marna Goldstein's multicolored, patterned photoscreen wall hangings have earned awards of merit at national textile exhibitions. In any given contemporary surface fabric exhibition, one may expect to see several artworks which incorporate this process.

The color xerox transfer process is one of the most recently developed printing processes available to textile artists. With this highly technological process, any multicolored image can be transferred simultaneously to the fabric without requiring separate applications for each color. The number of color xerox machines available to artists is limited. One of the first machines was acquired by Southern Illinois University, Carbondale, Illinois, where artist Joan Lintault has had the opportunity to explore the process and demonstrate its versatility.
Though the airbrush is not new to the advertising industry nor to painters, only recently has it been employed by textile artists to apply thin coats of dye to fabric to produce subtle gradations of color not attainable using former techniques. Diana Harrison of Great Britain used this process for developing a gradation of value on textiles exhibited in the Third International Exhibition of Miniature Textiles in 1978.

In the last 10 to 15 years, some artists have focused their talents on the exploration of new materials and techniques; but because of the relatively short time these materials and techniques have been available all possibilities for their art studio application have not been thoroughly explored. Instructional literature concerning new technology in art fabric techniques is not widespread. Perhaps, textile artists are spending more time making art rather than writing about it or teaching. If this is so, it is the author's hope that a more thorough exploration of the textile media will be the result.
"Mercerization is a process of finishing cotton by treatment in strong caustic soda solution, usually applied to impart a permanent high luster." Caustic soda, a strong alkali, causes cotton fibers to swell in circumference. This increase in width causes shrinkage (in the length of each cotton fiber) and, consequently, in the length of each cotton yarn or thread. John Mercer discovered the fundamentals of commercial mercerization while experimenting with caustic soda and cotton cloth in 1844. "Upon filtering a strong solution of caustic soda through cotton he noticed that the cloth shrunk and puckered and had a closed-up or 'fulled' appearance, with greater thickness and strength and increased dyeing capacity after the alkali was washed out." These new properties in cotton were not utilized by the textile industry at the time because of the scarcity of caustic soda, and later because the loss of yardage incurred by the shrinkage of the cotton fabric was considered too great.

Approximately 40 years later, chemist Horace Lowe discovered that cotton fabric held under tension during mercerization acquired a glossy appearance in addition to the beneficial effects obtained by Mercer. Tension prevented the fabric from shrinking, thus making mercerization a more feasible procedure for industrial application.

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3 Ibid.

4 Ibid., p. 374.
Caustic or plisse crepes represent another application of mercerization to piece goods, discovered by John Mercer and still practiced. These crepes are fabrics with a seersucker effect due to alternating plain and crinkled stripes, the latter produced by the shrinkage of the stripes between them by means of caustic soda.5

To produce this effect, stripes are either printed with a thickened, concentrated solution of caustic soda or with a resist material which allows only unprinted areas to shrink during later caustic soda treatment. "The style was first carried out by the firm of Garnier and Depouilly of Lyon in 1884."6 Plisse fabrics may include designs printed with dye or pigment. The author has found no evidence in her research that caustic soda was ever employed to print designs other than the plisse printing process which was used to impart an overall textural stripe effect on cotton fabric.

Increased dye receptivity has been a known feature of mercerized cotton ever since Mercer’s experiments. Caustic soda enables cotton to take up more color from a given dyebath than untreated cotton. The author has seen no examples of commercial fabrics utilizing the two-tone color design effects made possible by printing designs with caustic soda and, subsequently, immersing the fabric in a dyebath.

In the 1920's, the firm of Heberlein in Wattwil, Switzerland discovered that cotton fabric treated with solutions of caustic soda 53°Tw. at -10°C (14° F)7 became somewhat transparent. Cotton treated in this manner has become known as "parchmentized" cotton or "mock voile," because of its similarity to this fabric.

5Ibid., p. 387.


In 1959, Wilson A. Reeves and Charles H. Mack described a process used to obtain durable creases in cotton cloth using caustic soda and a household iron. The durable crease process was intended to produce a "wash-and-wear finish" for "household and apparel fabrics." Since then, cotton has been replaced by polyester/cotton blends in instances where long-lasting creases are desired. Polyester/cotton blends maintain permanent creases set by means of heat which slightly melts the polyester and fuses the creases into the fabrics.

The shrinking action of mercerization without tension, referred to as "slack mercerization," has been used to impart special effects to cotton cloth. Cotton knit fabric has been condensed by shrinkage in caustic soda and then scoured to raise surface fibers, developing what is known as "sueded cotton fabric." This has been used to make cotton "suede" gloves. "According to some patents a wool-like character may be imparted to cotton, . . . due in part to. . . an increased resiliency or loftiness which, with a slight harshness, must be largely responsible for any wool effect," Caustic soda has been used to shrink "open weave, low count gauze to produce 'semi-elastic' bandage." It must be emphasized that the above caustic soda processes have been developed specifically for the textile industry. Textile trade journals have made no mention of the possibilities of caustic soda processes being conducted in the home or studio. That is not unusual because they are strictly concerned with production on a large commercial scale.

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LABORATORY EXPERIMENTS

The author initiated her research by conducting a series of experiments on cotton fabrics using caustic soda solutions. The purpose of the research was threefold: (a) to become acquainted with caustic soda and its reaction, (b) to experiment with techniques related to its applications within the textile industry, and (c) to determine the safest and simplest methods for art studio application of caustic soda processes to create textile design effects on cotton.

Preparation of Caustic Soda Solution

Caustic soda must be in solution in order to be absorbed by the fabric. The strength or concentration of caustic soda in a solution is most often measured in degrees Twaddle (°Tw.). This unit of measurement appeared regularly in the texts and journals reviewed. The author referred to degrees Twaddle/specific gravity conversion table in Knecht and Fothergill. Each degree Twaddle has a corresponding unit of specific gravity. Using a hydrometer, it was possible to mix caustic soda solutions to the exact degree Twaddle desired.

Since caustic soda solutions can reach the boiling point during preparation, pyrex glassware was necessary to prevent breakage of containers. A one-liter graduated cylinder was an excellent mixing vessel because it was tall enough for use with a hydrometer. The graduated cylinder was filled with approximately 800 milliliters of cold water. The hydrometer was then placed in the water. Caustic soda pellets were added several tablespoons at a time and dissolved by stirring with a glass rod. Additional caustic soda pellets were added gradually until the hydrometer registered the appropriate specific gravity for the solution. After being allowed to cool, the solution was poured into polyethylene liter bottles and carefully labeled.

Testing with Different Strengths of Caustic Soda

The first tests were made to determine the effects of different combinations of caustic soda on the degree of shrinkage obtained in loosely woven cotton fabrics. The fabrics tested were cheesecloth and buckram. Loosely woven fabrics were chosen because they would allow maximum contraction of the yarns and, therefore, they would exhibit the most radical shrinkage. Six-inch squares of fabric were saturated with caustic soda solutions at concentrations of 15°Tw., 30°Tw., and 60°Tw. Although most shrinkage took place within the first 30 seconds, the caustic soda was allowed to remain in the fabric for about 5 minutes, or until it appeared that the fabric would shrink no further. The results of the tests are shown in Table 1.

Table 1. Effects of different strengths of caustic soda on loosely woven cotton fabrics

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Original Size</th>
<th>15°Tw. Size After Application of NaOH</th>
<th>30°Tw. Size After Application of NaOH</th>
<th>60°Tw. Size After Application of NaOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheesecloth</td>
<td>6&quot; x 6&quot;</td>
<td>5 3/4&quot; x 5 1/4&quot;</td>
<td>4&quot; x 3 5/8&quot;</td>
<td>3 3/4&quot; x 3 1/4&quot;</td>
</tr>
<tr>
<td>Buckram</td>
<td>6&quot; x 6&quot;</td>
<td>5 1/2&quot; x 5 1/2&quot;</td>
<td>4 3/4&quot; x 4 1/2&quot;</td>
<td>4 1/4&quot; x 4 1/4&quot;</td>
</tr>
</tbody>
</table>

The most marked shrinkage occurred in the samples treated with caustic soda 60°Tw. Since maximum shrinkage was desired in order to create strong visual effects, caustic soda 60°Tw. was used in all subsequent experiments involving shrinkage of cotton fabric. In the textile industry caustic soda 105°Tw. is used in the production of plisse fabric. An Iowa State University chemistry professor, Wilbert Hutton, Ph.D., warned the author that solutions at this concentration would frost glass and eventually cause the sodium silicate in the glass to precipitate into the caustic soda solution. This would be extremely hazardous to use without proper scientific equipment and supervision. As a measure of safety, the author decided to use caustic soda in concentrations no higher than 60°Tw.
Neutralizing Caustic Soda

A solution of 2% sulphuric acid ($H_2SO_4$) is used in the textile industry to "sour" or neutralize the caustic soda remaining in the fabric after treatment. The neutralization is essential to prevent a slow deterioration of the fibers. Industrial rinsing processes would include: (a) flooding with water to remove all of the caustic soda possible; (b) souring in a bath of 2% sulphuric acid to neutralize the caustic soda; and (c) washing in soap and water to remove the sulphuric acid.

A chemistry assistant at Iowa State University prepared for the author a solution of 50 parts (by volume) of sulphuric acid and 950 parts (by volume) of water. The author mixed this with an additional 1,000 parts of water. The rinsing procedure outlined above was tested using small cloths saturated with caustic soda 60°Tw. All traces of caustic soda were effectively removed from the fabric. In another test, the acid was applied with a brush, limiting the application to areas of the fabric which contained caustic soda. This method was successful with the cheesecloth, and had the advantage of reducing waste of the acid solution. The heavier buckram could not absorb enough acid applied in this manner to neutralize the caustic soda adequately.

Because sulphuric acid is not readily available to lay persons, and because of the hazards involved in mixing it with water, it was suggested to the author that acetic acid be tested as an alternative. White vinegar (5% acidity) was substituted for sulphuric acid and the same rinsing procedures followed. Although it required a greater amount of vinegar to remove the same amount of caustic soda from the cloth, the vinegar proved to be a successful alternative to the sulphuric acid solution.

Goldthwait reported that "an alternative is to wash exhaustively with water alone."\(^\text{13}\) It was found that the amount of time and water required for this procedure was not worth the reduced expense.

\(^\text{13}\) Ibid., p. 378.
Thickeners for Caustic Soda

There is, at times, a need for some control of the areas which will be in contact with the caustic soda applied to the fabric through a stencil, screenprint, squeeze bottle, or blockprint. Caustic soda can be thickened to facilitate these application methods. Since a thickened solution does not spread or leach into untreated areas of the fabric, a definition of line and detail can be achieved. A thickened caustic soda solution has the consistency of a conventional printing paste.

Literature reviewed mentioned gum Senegal, Schiraz gum, and British gum as the commonly used thickeners employed in the past by the textile industry. Since most of the literature discussing caustic soda textile design effects is dated, the author contacted the American Association of Textile Chemists and Colorists, who recommended manufacturers of thickeners used by the textile industry today. Manufacturers contacted sent samples of their products.

Polyprint S.E., manufactured by Polymer Industries in Greenville, South Carolina, is a highly viscous synthetic emulsion which comes ready to be thinned to printing consistency by adding caustic soda. An effective printing paste was mixed using the following proportions:

1 part (by volume) Polyprint S.E.
3 parts (by volume) caustic soda solution 60°Tw.

Nadex 360, manufactured by National Starch and Chemical Corporation in Bridgewater, New Jersey, is a corn dextrin product which comes in powdered form. The powder was stirred into the caustic soda solution and the mixture thickened after standing for several hours. The following proportions worked well:

1 part (by volume) Nadex 360
8 parts (by volume) caustic soda solution 60°Tw.

Using these two commercial thickeners, application was performed successfully with paintbrush, stencil, squeeze bottle, screenprinting, linoleum block, and canning. In order to obtain maximum shrinkage of the goods, the cloth was not held under tension. The time required for complete fabric shrinkage varied, but generally took longer than for the
samples treated with unthickened solutions of caustic soda. The author assumed this was because a greater amount of time was needed in order that the thickened caustic soda could thoroughly permeate the cotton fibers.

The author discovered unique considerations in printing thickened caustic soda using screens and stencils. When using the stencil, it was necessary to work very quickly, filling in the perimeter of the design first, to prevent the immediate shrinking action of the caustic soda from distorting subsequently "applied" areas of the image. The author discovered that a repeat pattern was difficult, if not impossible, to print using caustic soda and a screen. As each print was made by the screen, the affected area immediately shrank, causing problems in proper registration of subsequent unit prints. In addition to this, the thickened caustic solution took days to dry on the fabric, therefore, extending the time required to print yardage from hours to days.

Still another thickening agent was tested. Sodium alginate, used to thicken dye solutions, was prepared using two procedures. In the first experiment, one-fourth teaspoon sodium alginate powder was stirred into three tablespoons caustic soda 60°Tw. The particles of sodium alginate did not dissolve in the caustic soda and the solution did not thicken. In the second procedure, one-half teaspoon sodium alginate was stirred into one-half cup water to prepare a thickened emulsion before it was mixed with an equal amount of caustic soda 60°Tw. A printing paste or suitable consistency was formed. When printed on fabric, however, the caustic soda separated from the alginate and leached into the fabric which adjoined the printed area. After use, the caustic soda eventually decomposed the sodium alginate, and the mixture reverted to a thinner liquid consistency.

The author concluded that Nadex 360 and Polyprint S.E. were the most convenient thickeners to prepare, use and store (Table 2).
### Table 2. Thickeners tested with caustic soda

<table>
<thead>
<tr>
<th>Thickener</th>
<th>Effectiveness</th>
<th>Source</th>
<th>Ease in Preparation</th>
<th>Shelf Life After Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyprint 3.E.</td>
<td>Excellent</td>
<td>Manufacturer Easy</td>
<td>Indefinite</td>
<td>Indefinite</td>
</tr>
<tr>
<td>Nadex 360</td>
<td>Poor</td>
<td>Manufacturer Easy</td>
<td>Indefinite</td>
<td>Indefinite</td>
</tr>
<tr>
<td>Sodium alginate</td>
<td>Poor</td>
<td>Craft supplier Easy</td>
<td>1-2 hours</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3. Resists tested with caustic soda

<table>
<thead>
<tr>
<th>Material</th>
<th>Effectiveness</th>
<th>Source</th>
<th>Ease in Preparation</th>
<th>Shelf Life After Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gum arabic</td>
<td>X</td>
<td>Craft supplier</td>
<td>Slightly difficult</td>
<td>Months if refrigerated</td>
</tr>
<tr>
<td>Cornstarch</td>
<td>X</td>
<td>Grocery store</td>
<td>Easy</td>
<td>2-4 weeks if refrigerated</td>
</tr>
<tr>
<td>Gelatin</td>
<td>X</td>
<td>Grocery store</td>
<td>Easy</td>
<td>1 month if refrigerated</td>
</tr>
<tr>
<td>Acrylic polymer</td>
<td>X</td>
<td>Art supply store</td>
<td>None necessary</td>
<td>Indefinite</td>
</tr>
<tr>
<td>Sodium alginate</td>
<td>X</td>
<td>Craft supplier</td>
<td>Easy</td>
<td>1 month if refrigerated</td>
</tr>
</tbody>
</table>
Resists for Caustic Soda

Certain materials painted or printed on fabric can make the fabric resistant to the shrinking action of caustic soda. The following resist materials were discussed in the literature reviewed: gum Senegal, gum arabic, gum Gedda, and British gum. However, these natural gums, once economical to use, are now relatively expensive and difficult to obtain. One pound of gum arabic was purchased for $12.95. Other available materials tested were cornstarch, acrylic polymer gloss medium, gelatin, and sodium alginate (Table 3).

Each was prepared by its appropriate, individual method. The gum arabic was prepared by stirring four tablespoons of gum arabic powder into one and one-half cups water. This mixture was boiled, stirring constantly, for 15 minutes until it reached a syrupy consistency. To prepare the gelatin resist, two envelopes (two tablespoons) gelatin powder were stirred into one-half cup boiling water. The sodium alginate resist was mixed by adding one-half teaspoon sodium alginate powder into one-half cup water after which the mixture was stirred and allowed to thicken overnight. The cornstarch resist was prepared by dissolving one-fourth cup cornstarch in one-third cup cold water, then adding three cups of rapidly boiling water while stirring constantly. After boiling for a few minutes, the mixture was removed from the heat and allowed to cool.

All resists were brushed onto the fabric through a stencil of circular shape made out of waxed oaktag paper. An electric fan directed toward the fabric hastened the drying time. Once the resist material was dry, the fabric was treated with caustic soda 60°Tw. In one test, caustic soda was brushed carefully onto the fabric, making sure not to brush over the resist area. In a second test, the fabric was completely saturated with caustic soda. In each test the caustic soda was allowed to remain in the fabric for 15 minutes, after which the test pieces were rinsed in the usual manner.

The gum arabic withstood the action of the caustic soda in both treatments, was easy to apply and remove afterward. The cornstarch
resist dissolved when the caustic soda was brushed over it, and the fabric shrank. When the caustic soda was applied around the perimeter of the resist, the cornstarch was able to withstand the action of the caustic soda throughout the 15 minute duration of the test. The gelatin proved to be an excellent resist. After use it could be stored in the refrigerator, and melted again to be reused. (One limitation with the gelatin resist is that it can dissolve around the edges if kept in contact with the caustic soda for over an hour. It is likely that the cornstarch resist would also dissolve.) The sodium alginate was easily dissolved by the caustic soda and did not function as a resist. The acrylic polymer gloss medium dried to an insoluble, stiff plastic finish which became permanently fused to the fabric. These qualities can be desirable when creating sculptural forms in fabric.

Caustic Soda Durable Crease Finish

The simple procedures outlined by Mack and Reeves for imparting the durable crease finish to cotton cloth were very easy to duplicate. Using bleached mercerized cotton sheeting fabric, the process involved four steps. The fabric was given a temporary crease at the desired location by ironing. The crease was moistened by brushing on caustic soda 30°Tw., and was ironed dry. The fabric was rinsed to remove the caustic soda and line dried.

When the fabric was ironed, the caustic soda released an acrid smoke. The author wore a respirator, and used an electric fan to direct the smoke out an open window. The fabric containing caustic soda, when ironed, was stained a brownish yellow color. Much of the stain was removed during subsequent rinsing and mild bleach solution removed the remainder.

Caustic Soda and Dye Receptivity

To determine the dye receptivity of cotton fabric treated with varying strengths of caustic soda, three specific areas of a fabric were treated with solutions of caustic soda 15°Tw., 30°Tw., and 60°Tw. The fabric was rinsed to remove the caustic soda and line dried. The fabric was immersed and agitated in a Procion fiber reactive dyebath for
several minutes, then rinsed until the water ran clear. The dyes were not fixed.

The capacity for dye-receptivity increased parallel with the concentration of caustic soda in the solution. The area treated with caustic soda 15°Tw. was the same light value as the untreated area. Areas treated with caustic soda 60°Tw. yielded very dark values, a great contrast to the light value of the color produced in untreated areas of the fabric.
DISCUSSION OF ORIGINAL ARTWORK PRODUCED USING CAUSTIC SODA

The patches of Fairy Quilt (slides 1 and 2) illustrate how the increased dye receptivity of cotton due to caustic soda treatment can be used to create diverse color combinations. A simple design was printed on swatches of cheesecloth using caustic soda at 60° Tw. Six dyebaths were prepared: yellow, navy blue, turquoise, lime green, and two red. Each swatch of fabric was agitated in several different dyebaths. Because the printed areas absorbed more color, the order in which the swatches were dipped in the various colors greatly affected the final color combination of each swatch.

The somewhat voluptuous quality of the breastplate in Iowa Fertility Vestment (slides 3 and 4) was achieved by shrinking the motifs with caustic soda. This resulted in a puffing of the adjacent fabric. When this doubled fabric was later stuffed with seed corn, the "puffing" facilitated the smooth, unpuckered transition from the areas of bulbous relief to the flat, two-dimensional motifs.

Copper Traces (slides 5 and 6) illustrates the capacity of cotton fabric to retain creases and shapes created when using the caustic soda durable crease technique. The fabric was molded around pennies which oxidized during the subsequent caustic soda treatment and created the blue-green accents of color on the perimeter of each disk.

Caustic soda was used to treat a single layer of fabric to create the Bas Relief (slides 7 and 8) wall hanging. A design was applied with polymer gloss medium which stiffened the design area and acted as a resist during the caustic soda treatment. The stiffened shapes were forced into a curved position to accommodate the shrinkage which occurred in the surrounding fabric.

Minoan Casement (slides 9 and 10) illustrates the opaque effect obtainable by treating a fine cotton gauze with caustic soda. The simple
machine-stitched checkerboard design was made more interesting by application of caustic soda to alternating squares, and to the spirals. When the squares shrank, concave and convex shapes resulted which softened and puckered the surface of the piece.

Polymer gloss medium was used as a resist and to stiffen the gray shapes in Tension Game (slides 11 and 12). The rest of the piece was shrunk with caustic soda to create a two-dimensional background surface across which the three-dimensional gray shapes ripple or undulate. The polymer gloss medium holds the "ripples" in position, checking the natural tendency of the fabric to drape downward.

Caustic soda was employed in conjunction with cotton and polyester fabrics to produce the unique fabric used to construct Valentine Coat (slides 13 and 14).

Pemaquid I (slides 15 and 16) was created using the same procedure as Valentine Coat. The resulting fabric, however, was very different due to the fact that acetate fabric was used instead of polyester as the top layer of fabric. Several difficulties were encountered during the caustic soda treatment. The caustic soda caused the acetate to release dye which partially obliterated the colored design created by machine stitching. The acetate partially deteriorated and the result, although interesting in texture, is not very durable.
SUMMARY

The author conducted experiments based upon information obtained from the review of literature concerning the applications of caustic soda to cotton fabrics in the textile industry. The procedures describe how to make and use caustic soda thickeners, appropriate resist materials that will withstand caustic soda, and use of caustic soda to develop durable creases. The author also discussed the changes in dye receptivity of the cotton fibers due to treatment with caustic soda.

The author has prepared an instruction manual for advanced textile artists giving directions for proceeding with the preparation and application of caustic soda to cotton fabrics. Included are the numerous safety precautions that the textile artist must observe in the studio. The manual is envisioned as being a part of the information given to textile artists who attend educational workshops conducted by the author on the subject of designing through the use of caustic soda.

This study has shown that caustic soda can be used by artists to produce varied effects in cotton fabric not obtainable when using other materials and techniques. Because handling caustic soda can be hazardous, its use should be limited to mature artists experienced with textile media and techniques. A great deal of patience and concentration is necessary while caustic soda is in use. It is a capricious substance in that its successful application can be seriously affected by such variables as speed of application, the kinds of tools used, and materials with which it is used. As stated in the author's manual for textile artists, "What works in a small sample may not work in a large artwork."

The author limited her research to the effects of caustic soda applied to commercially woven fabrics. It could also be used creatively by weavers. For example, if a weaving were constructed of synthetic and cotton yarns, only the cotton fibers would shrink during subsequent
caustic soda treatment. This would cause changes in fiber tension which would result in three-dimensional effects. The author believes that some day a study should be undertaken to determine the varied effects obtainable using caustic soda in conjunction with hand weaving.

Occasional difficulties were encountered while producing several of the artworks illustrated in this thesis. This reflects the fact that these techniques are very new and are still in the experimental stage. The knowledge gained through this study will be used by the author as a basis for continued research and experimentation with caustic soda to broaden and perfect its capabilities as a tool for the textile artist.
BIBLIOGRAPHY


APPENDIX A: PHOTOGRAPHIC ILLUSTRATIONS OF SELECTED TEST RESULTS
Figure A.1. Shrinkage produced by caustic soda 60°Tw, in a six-inch square of cheesecloth
Figure A.2. Actual size of cheesecloth weave before and after treatment with caustic soda 60° Tw.
Figure A.3. Dye receptivity of cotton treated with caustic soda 15°Tw., 30°Tw, and 60°Tw.
APPENDIX B: CAUSTIC SODA APPLICATIONS IN THE STUDIO: A MANUAL FOR ADVANCED TEXTILE ARTISTS
CAUSTIC SODA APPLICATIONS IN THE STUDIO:
A Manual For Advanced Textile Artists

Caustic soda, also called NaOH, sodium hydroxide, or "household lye," is a strong alkaline material with considerable potential as a design tool for artists working with textile media. Briefly stated, caustic soda causes cotton fibers to swell in circumference, with a resulting shrinkage in length. When it is applied to cotton fabric, the treated areas exhibit a marked shrinkage which can be controlled to produce unusual visual and textural effects.

Mercerization is a commercial caustic soda process which strengthens cotton and improves its hand and luster. Plisse, a commercial fabric resembling seersucker, utilizes caustic soda to shrink narrow stripes, causing the unshrunk stripes to crinkle in an overall crepelike texture. In the hands of an experienced textile artist, caustic soda is capable of producing far more varied and artistic results.

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TOOLS AND SUPPLIES

Much of what you will need is already in your kitchen or studio.

Caustic soda can be applied to the cloth using tools for printing and dyeing.

PARTIAL LIST OF MATERIALS

caucistic soda pellets
unflavored gelatin
Polyprint S.E.
Nadex 360
gum arabic
loosely woven, unmercerized cotton
nylon bristle brushes
glass stirring rods
plastic or vinyl drop cloths
tools for printing and dyeing
chemist's rubber gloves
safety glasses
respirator
chemical apron
liter graduated cylinder
hydrometer (sp. gr. 1.0 to 2.0)
polyethylene bottles
large lidded enamel pots
white vinegar (minimum 1 gallon)
old household iron
bowls and basins
electric fan

A SAFE RULE OF THUMB: USE ONLY GLASS, ENAMEL, OR SYNTHETIC TOOLS. THEY ARE EASY TO CLEAN, MAINTAIN, AND ARE NOT AFFECTED BY CAUSTIC SODA,

DISCUSSION OF SELECTED MATERIALS

Caustic soda pellets: can be purchased at chemical suppliers. 5 lbs. will last a long time. Household lye can be purchased at grocery stores, but the cost is prohibitive.

Liter graduated cylinder: necessary to prepare safely the caustic soda solution. The chemical reaction may cause it to boil. Available at laboratory supply stores.

Hydrometer: necessary to gauge the strength of caustic soda solutions during preparation.

Polyprint S.E., Nadex 360: commercially produced thickeners for caustic soda.

Chemist's apron, safety glasses, respirator, and heavy-duty gloves: ESSENTIAL! Dishwashing gloves will eventually corrode.

Old household iron: caustic soda may corrode the iron; you should never use your good iron with it.
SAFETY PRECAUTIONS

Caustic soda is a powerful alkali. Solutions of 50% (100 T/) or more—stronger than you will be using—can etch glass. Concentrations used in the textile studio can corrode or destroy materials such as wood, sponge, leather, aluminum, "protective" lacquers, and your skin. This will result in dangerous sores susceptible to infection.

AT ALL TIMES CAUSTIC SODA IS IN USE, GREAT CARE MUST BE TAKEN TO PROTECT YOURSELF AND YOUR SURROUNDINGS.

--Wear safety glasses, gloves, and protective clothing.
--To avoid inhaling hazardous dust, wear a respirator when preparing caustic soda solutions.
--Have a vessel containing vinegar nearby with which to neutralize spills as they occur,
--Work in a well-ventilated area.
--Clearly label caustic soda containers "poison" as well as with information pertaining to the strength of the solution. It would be wise to include the emergency measures to be taken in case of an accident.
--Mark tools and materials "for use with caustic soda only" to prevent invisible or accidental residue from causing other damage.
--Prevent children and pets from having access to the work area while caustic soda is in use.
--Clean up immediately after using caustic soda. It is a clear liquid which possibly could be overlooked at a later time. Damage takes place in a short period of time.
--Replace caps on all containers immediately after use.
--Make sure that wooden parts of screens, blocks, squeegees, etc., are protected by a heavy coat of synthetic varnish.
--Screens for printing should contain synthetic, not silk, fabric.
--Be sure wooden floors are covered with newspapers and plastic to protect against spills.
--Store caustic soda away from foods and out of reach of children.
--Do not eat or smoke while handling caustic soda.
PREPARING CAUSTIC SODA SOLUTIONS

The strength of a caustic soda solution is measured in degrees Twaddle (°Tw.). Each degree Twaddle has a corresponding specific gravity (sp. gr.). Using a hydrometer which measures specific gravity, it is possible to mix caustic soda solutions to the exact degree Twaddle desired.

A solution of caustic soda 60°Tw. (NaOH 60°Tw., sp. gr. 1.3) will produce a marked shrinkage in loosely woven cotton fabrics. This is the recommended strength to use. About 2 cups of caustic soda pellets will be needed to mix 1 liter of caustic soda having the strength of 60°Tw.

A WORD ABOUT VINEGAR

Soap and water will not remove caustic soda. It is a strong alkali, and MUST be neutralized by using an acid. Vinegar (acetic acid) is a satisfactory neutralizing agent and will not damage work surfaces or fabrics. Keep it easily accessible in case of spills.

BEFORE YOU BEGIN:

Be sure your work area is well protected and there is a good supply of water and vinegar nearby.

PROCEDURE:

1) Fill a pyrex liter graduated cylinder about 800 ml with cold water. Place the hydrometer in the water. (At this point be sure you are wearing safety glasses, respirator, gloves, and protective clothing.)

2) Add caustic soda pellets slowly, about 1/4 cup at a time, stirring with a glass rod after each addition. The mixture will become very hot.

3) The hydrometer will slowly rise as more pellets are added to the solution. It will take approximately two cups pellets to attain the specific gravity of 1.3 (60°Tw.).

4) Once the correct specific gravity is registered on the hydrometer, let the solution cool before pouring into a liter polyethylene bottle for storing.

5) Label the bottle carefully and clean up the work area, first using water, then a little vinegar, and then soap and water.

SPECIFIC GRAVITY --- DEGREES TWADDLE CONVERSION CHART

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NEUTRALIZING CAUSTIC SODA

After treating the fabric, neutralization of the caustic soda will be an essential part of your procedure. It prevents the slow deterioration of the cotton fibers, and possible burns during later handling. Using vinegar, thoroughly remove caustic soda from any tools which have been employed.

PREPARATION OF WORK AREA

Be sure there is an ample supply of water and vinegar. Pour 1 gallon or more of white vinegar into a large, lidded enamel pot. This will become your souring bath. It can be stored and reused many times. As you become familiar with the rinsing process, you will know when the vinegar needs to be changed. In the absence of more appropriate facilities, a bathtub provides an excellent receptacle for vinegar and rinse water.

PROCEDURE:

1) Still wearing protective clothing, including gloves, squeeze caustic soda out of the fabric.
2) Flood with cold water to remove all possible caustic soda. (Hot water may reverse the shrinkage produced by the caustic soda.)
3) Immerse the fabric in the vinegar bath and agitate for several minutes. Squeeze out excess vinegar.
4) Wash in soap and water to remove vinegar.
5) Line dry.

HOW TO TELL WHEN CAUSTIC SODA HAS BEEN COMPLETELY REMOVED FROM THE FABRIC:

Caustic soda creates a slimy coating on the fabric when it is wet. After the fabric has been agitated in the vinegar, take off a glove and test the texture. If it no longer feels slimy, the caustic soda has been removed. If some caustic soda remains in the fabric, more agitation in vinegar is necessary or fresh vinegar may need to be added.
TECHNIQUES USING CAUSTIC SODA

liquid caustic soda

"Plain" liquid caustic soda can be applied to the fabric using dye application tools including nylon bristle brushes and linoleum blocks. (Linoleum blocks should be protected with synthetic varnish to prevent deterioration of the linoleum.) Like unthickened dyes, caustic soda will leach into areas of the fabric adjoining the treated areas. Although most of the shrinking action of the caustic soda takes place in the first 30 seconds, a small amount of additional shrinkage will occur. A wide nylon bristle brush is an excellent tool with which to apply the caustic soda.

thickeners

At times when more control of the caustic soda is necessary, a thickened solution is easy to prepare. Starch or seaweed derivatives normally used with dyes are dissolved by caustic soda; however, there are commercial thickeners which are made specifically for caustic soda.

Polyprint S.E. is a highly viscous gum which comes prepared, and can be thinned to printing consistency by adding caustic soda solution. The following proportions will yield a good printing paste:

1 part (by volume) Polyprint S.E.
3 parts (by volume) NaOH 60°Tw.

Mix together thoroughly.

Nadex 360 is a powdered corn dextrin product which is added directly to the caustic soda.

1 part (by volume) NADEX 360
8 parts (by volume) NaOH 60°Tw.

Mix together thoroughly and let stand overnight to thicken.

WHEN USING THICKENED CAUSTIC SODA:

--A greater amount of time is required for shrinkage to occur. This is perhaps because it takes longer for the caustic soda to permeate the cotton fibers.

--Screenprinting, squeeze-bottle, canning, linoleum block printing, and stenciling techniques are all possible using thickened caustic soda.

LIMITATIONS:

It is difficult, if not impossible, to print yardage with thickened caustic soda for two reasons:

1) As each print is made by screen or block, the affected area immediately shrinks, which causes problems with proper registration of subsequent prints.

2) The thickened caustic soda takes many hours to dry on the fabric, therefore, greatly extending the time required to print.
THIS CAN CREATE PROBLEMS:

Small accidental spills of caustic soda may not be noticeable on a fabric dyed prior to treating with caustic soda. However, if dyed after the caustic soda treatment, those small spots will be a different color than the background and, therefore, much more noticeable. Extreme care must be taken if this process is to be employed successfully.

**durable crease**

Before polyester/cotton blends became popular for permanent press fabrics, caustic soda was used to impart a durable press finish to cotton goods. For this procedure mercerized cotton is necessary. (Unmercerized fabric will pucker at or near the crease.) It is essential to work in a well-ventilated area and wear a respirator.

Four steps must be followed:

1) Give the fabric a temporary crease at the desired location by ironing.
2) Moisten the crease with caustic soda 30°Tw. (sp. gr. 1.15).
3) Iron dry using an old iron.
4) Rinse, neutralize and line dry.

When ironed, caustic soda releases an acrid white smoke. Under no circumstances inhale this smoke! Make sure the work area is thoroughly aired before removing the respirator.

Using this technique, a wide variety of three-dimensional surfaces can be created. To remove a durable crease, remoisten the crease with caustic soda and press flat.

**LIMITATIONS:**

--When ironed, the caustic soda turns brown. If white fabric is used, this can be removed using a mild bleach solution.

--If the fabric is ironed too long or the temperature is too hot, the areas containing caustic soda may completely corrode.

--Because of the hazard produced by the smoke, this technique should be practiced only in protected areas with excellent exhaust fans or ventilation.

--This procedure seems to discolor many predyed fabrics.

--Since areas treated with caustic soda have a greater affinity for dyes, subsequent dyeing will result in uneven coloring on and around the creases where caustic soda has been applied.
resists

Certain materials, when applied to the fabric form, when dry, efficient resists to the shrinking action of caustic soda. Unflavored gelatin and gum arabic are two which are readily available.

A suitable resist using gum arabic can be prepared as follows:
1) Add 1 1/2 cups water to 4 tablespoons gum arabic.
2) Boil, stirring constantly, for 15 minutes, until the mixture is smooth and syrupy in texture.

The prepared gum arabic will last several weeks to months in the refrigerator. Although it will develop mold, this can be skimmed off prior to reuse.

This resist is suitable for brushwork. Johnson and Kaufman (Design on Fabrics, c. 1967, Van Nostrand Reinhold) give directions for preparing a thicker gum arabic emulsion.

Gelatin has the advantage of lasting an extended period of time when stored in the refrigerator. It can be remelted over heat for reuse.

2 envelopes (2 tablespoons) gelatin
1/2 cup boiling water

Add the gelatin and stir until the gelatin is dissolved. Let cool before using.

WHEN USING CAUSTIC SODA RESISTS:
--Resists should be painted on the fabric while in liquid form, in order to penetrate the fabric entirely.
--Check the reverse side of the fabric and add more resist if some parts of the resist area are not completely covered.
--Let the resist dry thoroughly before treating with caustic soda.
--Rinse and neutralize in the usual fashion. Both resists are water soluble.

dye effects

Cotton fabric treated with caustic soda will absorb dye more quickly and retain more color than untreated cotton in the same dyebath. This capacity for dye receptivity increases parallel with the concentration of caustic soda in the solution applied.

A shrunk design can be further enhanced by dyeing the fabric. The shrunk portions of the fabric will dye several shades darker.
CONCLUDING REMARKS

WARNING!! Caustic soda is a hazardous material. Take every precaution, PLEASE.

Caustic soda is a capricious substance. What works in a small sample may not work in a larger artwork. Conduct many tests before committing time and materials to a major piece. Be prepared for occasional disappointments.

These are not techniques for beginning or casual textile artists. Proper use of caustic soda requires forethought, strict adherence to precautions and procedures, and, above all else, concentration. However, the novel results—textural, structural, and color effects—are exciting! Your time, expense, and consternation will be richly rewarded.

SUPPLIERS

To purchase variously loosely woven cotton fabrics in bulk quantities (min. 20 yards), write for samples to:

James Thompson & Co., Inc.
3010 Willow
Franklin Park, IL 60131

To order thickeners for caustic soda:

Polyprint SE Polymer Industries
P.O, Box 2184 Roberts Road
Greenville, NC 29602

Nadex 360 National Starch and Chemical Corp,
10 Finderne Avenue
Bridgewater, NJ 08807
APPENDIX C: SLIDE IDENTIFICATION OF ORIGINAL ARTWORK
Slide 1. Fairy Quilt
48 x 48 in., 121.9 x 121.9 cm
Slide 2. Detail of Fairy Quilt
Slide 3. Iowa Fertility Vestment
32 x 44 in., 81.3 x 111.8 cm
Slide 4. Detail of Iowa Fertility Vestment
Slide 5. Copper Traces
28 x 21 in., 71 x 55.3 cm
Slide 6. Detail of Copper Traces
Slide 7. Bas Relief
29 x 43 in., 73.7 x 109.2 cm
Slide 8. Detail of Bas Relief
Slide 9. Minoan Casement
51 x 26 in., 129.5 x 66 cm
Slide 10. Detail of Minoan Casement
Slide 11. Tension Game
96 x 44 in., 243.8 x 111.8 cm
Slide 12. Detail of Tension Game
Slide 13. Valentine Coat
(woman's size medium)
Slide 14. Detail of Valentine Coat
Slide 15. Pemaquid I
48 x 58 in., 114.3 x 147.3 cm
Slide 16. Detail of Pemaquid I