A COMPARISON OF LAUNDRY METHODS ON CERTAIN COTTON FABRICS

by

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INTRODUCTION

The cleansing of fabrics has long been the problem of the women of the household. The laundress in early times washed her clothes in the running water of streams, the water dissolving out the dirt. Ancient Egyptian and Roman records furnish interesting history of early wash-days showing how clothes were stamped with the feet, beaten with clay and twisted and turned by hand. A progressive step was made when platforms were built on which the clothes were slapped and rubbed. Smoothing with a stick was used early as an ironing process.

Centuries later in England and other European countries we find the laundress still beating and tramping her clothes in an effort to cleanse them. As this process was slow and required much labor, a cleansing agent was sought that would add its power to that of mechanical action. This agent was found when wood ashes, taken from the fire and covered with water, were added to the wash waters. Thus the potash of the ashes was dissolved and this aided in the cleansing process. However, its action was destructive and to prevent this a crude form of soap was made by adding waste grease to retard the action of the potash.

Laundering as it is known in America has always been done in the home and thus lacks the pleasant stimulus of the community washday as it still exists in some European countries. When the washboard and wooden tub were abandoned and the mechanical washing machine came into the home, a call for better soap brought upon the market a multitude of new and purer forms. The modern use of soap demands that it be balanced in proportion of grease and alkali. However, no standardized procedure for home laundry work has been generally accepted and a variety of methods prevail.

Laundering is probably the most tiring and unpleasant of the tasks still remaining in the home. In many instances this work would gladly be turned over to any agency or institution outside the home that practiced economy of production and conservation of the life of the goods entrusted to its care.

A review of laundering as a commercial industry finds the first records of power laundries during the nineteenth century. Their establishment was brought about when parliament appropriated funds to relieve and check the outbreak of cholera in London. In the United States, gold seekers who rushed to California in 1849 made it necessary

to establish laundry service there. Early laundries met with open disfavor and opposition and for many years were confined to hotel and restaurant linens and men's clothing.

The commercial laundry has been notably successful in recent years. Conservation and scientific laundering of textiles is the goal of the better type of laundry and through its National Association much experimental research work has been done. Rapid improvement of equipment, cleansing material and methods of procedure have helped both the homemaker and the laundryman. With the available information, commercial launderies have developed a rather definite procedure for laundering, and are endeavoring to prove to the homemaker that power methods are as satisfactory and no more injurious to fabrics than home laundering. Efficient handling of white flat work has secured for them a large percentage of this service but many homemakers still believe that power methods are too severe for colored articles of wearing apparel. Advertisements and laundering directions often caution the purchaser to launder the articles at home in order to prevent undue shrinkage and loss of color.

Color variations, shrinkage, and change in tensile strength are modifications brought about through laundering.

A study of the comparative effect of power and home laundry methods on these qualities of colored cotton fabrics should be of interest to the homemaker.

Review of Literature

No study was found in the available literature that compared directly the effect on fabrics of power and home laundry methods. Johnson through the Laundryowners National Association has done much valuable research on many phases of the laundry problem but no published material was found of a direct comparison of power and home methods.

Kauffman (1931) compared the effect of perspiration, sunlight and various laundry methods on the fastness of color of several cotton fabrics. However, in this study no comparison was made between the effect of the laundry methods on the fabrics.

Doreē (1924) in a discussion of textiles and the modern family states that the life of material is determined by the effect of periods of long wear and of laundering by power methods. Also that many times after a trip to the laundry when materials break down, the laundry is blamed but that the breakage is due to poorly constructed cloth.

Viemont (1928) concluded that soaps affect the color

of the fabric much less than the tensile strength and shrinkage and that the apparent increase in tensile strength in many cases is due to the hydrolysis of free sodium carbonate in the soaps. Caustic alkali is formed which has a mercerizing effect upon the cloth during laundering.

Matthews (1921) in an article on fastness of color in textiles defines fast color as "one which must not be materially affected by influences to which it may be subjected as light, laundry, perspiration." He says "no color is absolutely fast to anything." "The consumer should understand that fast dyes are vat dyes and cannot be applied to all fabrics."

In a discussion of pre-shrinking at the Southern Textile Association meeting, Arrington (1932) stated that not since the adoption of fast colors on cotton has there been a greater advantage than that of shrinkage "complete to all practical purposes." At this meeting Mr. Arrington expressed the opinion "that in a very few years consumers will demand fully shrunk garments and that Sanforizing will eventually become a standard finishing operation such as mercerization is today."

Bureau of Standards Technological Paper No. 273 in a discussion of laundry practices states that the best work

in laundering is done when the fabric is restored to its original condition without change of color, appearances or feel, with the least damage to the material and the greatest saving of time.

McGowan (1929) says that it is not possible to have a standard laundry practice because different fibers have their peculiarities which make necessary changes either in temperature, time, solution or method of laundering.

Hampson (1932) makes the following statement: "Research has done much, probably it will do still more to bring about good laundering but there are limits beyond which the launderer cannot go unless he is given launderable fabrics. Much help would be given by a clear and accurate marking of all goods. Terms as 'Pure Silk,' 'Rayon,' 'Fast Dye' are very useful to a launderer."

The following standard information for use in wash room practices was published by the Laundryowners National Association. Bundles of clothes vary in the amount of dirt they contain, necessitating a careful sorting of garments before washing. The character of the water and detergents used is of prime importance. Water softening plants in connection with laundries render the water source the same as distilled water. The detergents most universally used

are soda ash and dry neutral soap powders.

The temperature of the water is of great importance. It is better to avoid too high a temperature at first. The moderate temperature of 100°F. has been chosen as optimum for the first bath. The second and third baths are higher, also the first three rinses should be between 140°F. and 160°F. with a gradual decrease in temperature until the last one is cold.

Johnson (1930), Director, Department of Research of the Laundryowners National Association, advises the use of twenty launderings as a test for a check on laundry methods. He believes that this represents approximately the number of times any article reaches the laundry in one year and can be run within a week's time. He claims that efficient laundry methods should not cause a loss of more than ten per cent in tensile strength for twenty launderings.

Purpose

The purpose of this study was to determine the effect on certain cotton fabrics of variations in methods of laundering by the power and the home laundries. The percentage loss in tensile strength, the amount of shrinkage per yard, and the loss and change of color were chosen as

the means of comparison. A definitely controlled laboratory test aided in checking results.

Johnson's test of twenty launderings was used. A loss of less than ten per cent in tensile strength for twenty launderings was made the standard for efficient laundering.

PROCEDURE

Cotton fabrics often used for house dresses, men's shirts and children's wear were selected for this study. Because of the large number of tests to be made it was necessary to limit the number and kinds of fabric. The six chosen were tan and green chambray; blue, green, tan and white broadcloth. All were of plain color and plain weave, quality and color being the basis for the selection. These fabrics were sold for pre-shrunk and color fast. However, no effort was made to determine the type of dye used.

The fabrics were analyzed according to the methods set up by the American Association for Testing Materials (Table I). All work was done in a laboratory in which standard conditions of relative humidity and temperature were maintained.

The Manhattan Steam Laundry was selected as repre-

Plate I

Explanation of Plate I

Specimens 1. Control fabrics used in comparing home power methods of laundering.

Specimens 2. Fabrics after twenty launderings by the power method.

Specimens 3. Fabrics after twenty launderings by the home method.

Specimens 4. Fabrics after twenty launderings by the laboratory method.

PLATE I

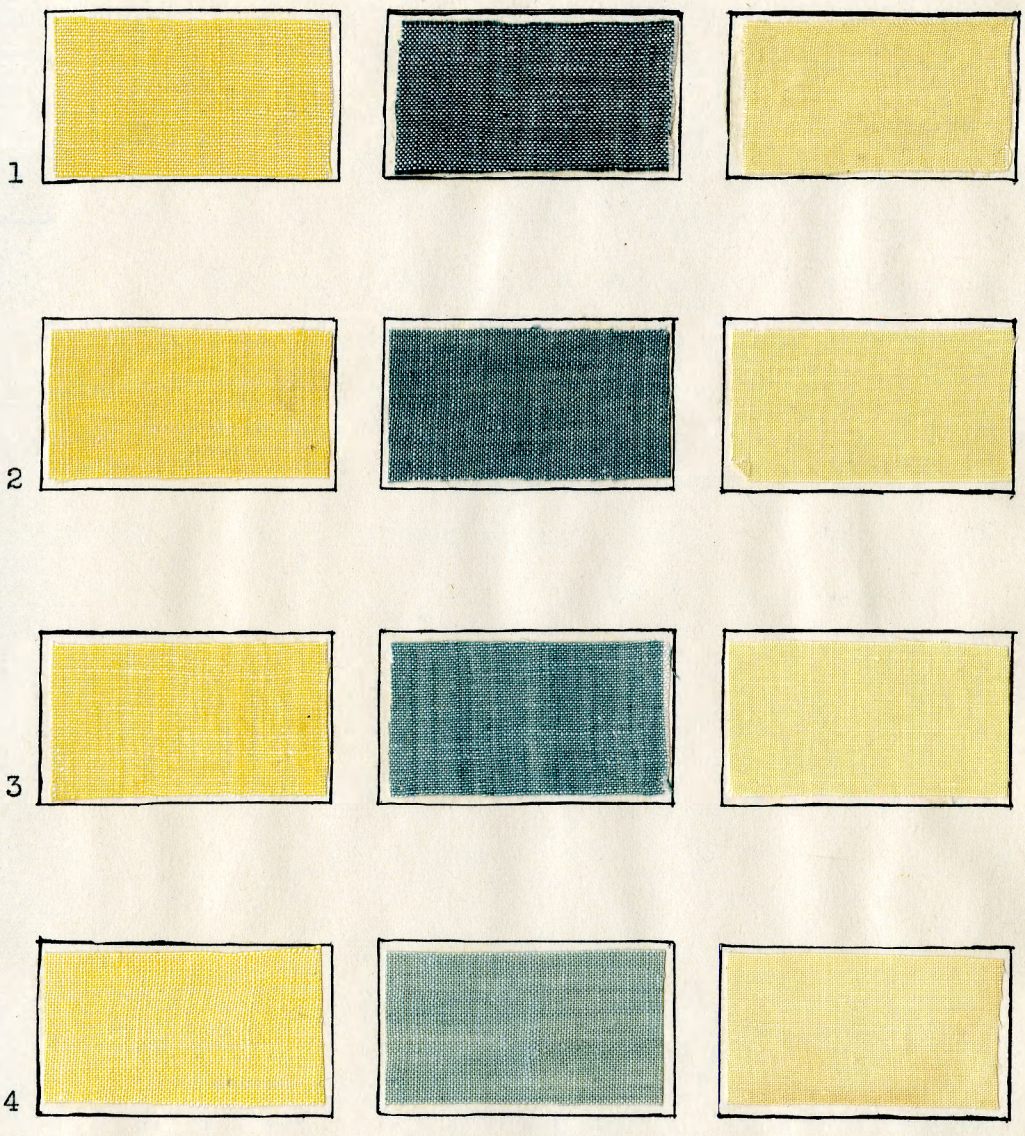


Plate II

Explanation of Plate II

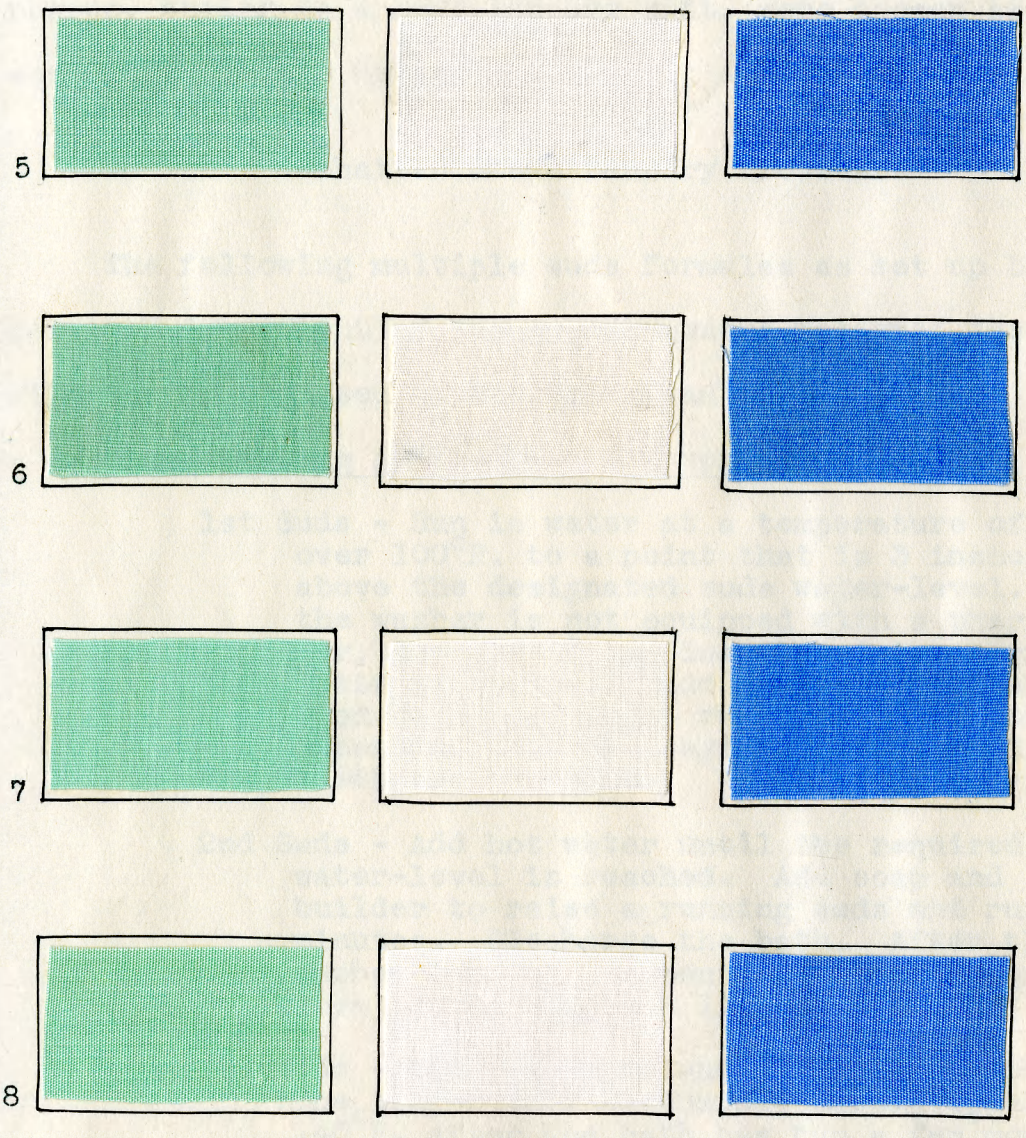
Specimens 5. Control fabrics used in comparing home and power methods of laundering.

Specimens 6. Fabrics after twenty launderings by the power method.

Specimens 7. Fabrics after twenty launderings by the home method.

Specimens 8. Fabrics after twenty launderings by the laboratory method.

PLATE II



sentative of power laundry methods. The two home management houses, acting as a home laundry unit, were chosen as representative of home methods.

Manhattan Steam Laundry Procedure

The following multiple suds formulas as set up by the research department of the Laundryowners National Association are those used by the Manhattan Steam Laundry.

White Wearing Apparel and Flatwork.

1st Suds - Run in water at a temperature of not over 100°F. to a point that is 3 inches above the designated suds water-level. If the washer is not equipped with a thermometer, the use of tap instead of lukewarm water is advised. Add soap and builder to produce a good suds, run 5 to 10 minutes, depending upon the degree of soil, and then discharge the bath.

2nd Suds - Add hot water until the required suds water-level is reached. Add soap and builder to raise a running suds and run 10 minutes. Discharge the bath. After the washer has run a moment or two, the temperature should approach 125°F.

3rd Suds - Add hot water and supplies as above. The temperature ordinarily should equal 140°F. after the bath has run a few moments. Discharge the bath at the end of 10 minutes.

4th Suds - Run in hot water to the designated suds level and add dilute Javel water at the rate of not more than 2 quarts of a 1 per cent solution per 100 pounds of material. Use less if possible. Add soap and builder, as necessary, and run 10 minutes. The

temperature of this bath ordinarily will range between 155° and 160°F. with a satisfactory hot-water supply.

1st Rinse - Run in a hot rinse at a suds water-level when the water-supply contains one or two grains of hardness. With soft water a high rinse should be used. Run for 3 minutes after the proper level has been reached.

2nd Rinse - Run a hot rinse at a rinse water-level and run for 3 minutes, after the correct level has been reached.

3rd Rinse - Repeat.

4th Rinse - Repeat.

5th Rinse - Follow with a warm (130°F.) high rinse for 3 minutes.

Sour and blue - Sour to the correct pH at a suds water-level at 120°F. for 5 minutes. Then raise the water to a rinse level with cold water, blue for 5 minutes, and drain the bath.

Light Blues, etc. (Cotton). The Light Blue classification, which includes grays, greens and lavenders as well as the light blues, are washed with the following general type of formula, the exact number of suds varying with the condition of soil.

1st Suds - Add water at a temperature not exceeding 100°F. to a point 3 inches above the designated suds water-level. Add soap and builder to produce a suds and run 10 minutes. Discharge the bath.

2nd Suds - Add water as before to a suds water-level and then soap and builder to produce a running suds. Discharge the bath at the end of 10 minutes.

3rd Suds - Repeat.

4th Suds - Repeat.

Note: Badly soiled loads may require an additional 10-minute suds at the same temperature.

1st Rinse - When the water-supply contains a few grains of hardness per gallon, add water at a temperature not exceeding 100°F. and drain the machine 3 minutes after the proper level has been reached. Otherwise run the customary high rinse into the machine.

2nd Rinse - Rinse at a high level at 100°F. and discharge the bath at the end of 3 minutes.

3rd Rinse - Repeat.

4th Rinse - Repeat.

5th Rinse - Repeat.

Sour - Sour to the correct pH for 5 minutes at a suds water-level at 95°F. Discharge the bath.

Note: If washers are handled at underloads, one or more rinses may be eliminated. Check by titration methods.

When handling so-called light fugitives, it is well to remember that as the temperature of the suds is increased, on the whole, the greater will be the tendency for bleeding to occur. At least those washers that are assigned to colored classifications should be equipped with properly operating thermometers if the washing temperature is to be controlled with any degree of accuracy. Javel water should not be used on this classification of colored goods under any consideration.

Household Laundry Procedure in Home Management Houses

I. Getting ready. Make sure that sufficient laundry supplies are on hand.

Sort clothes
Remove stains
Put clothes to soak
Shave 2 to 2½ bars of soap and cover with hot water.

II. Sorting - Soaking. Cold water if over night. Warm water if a short period. Soaking loosens the fibers so that they give up the soil more easily.

Tub 1 - Table linens; tea towels; face towels; white dresser scarfs
Tub 2 - Sheets; pillow cases
Tub 3 - Bath towels; wash clothes; white scrub cloths
Pans - Colored scrub cloths
Arrange equipment to save steps and motions.

III. Washing. Washing machine filled 2/3 to 3/4 full of hot water or to the water line on the tub. Add 1/4 to 1/2 cup of Sal Soda (amount depending on the quantity and hardness of the water) dissolved in hot water. Add enough soap solution to make a good suds.

1st washer - Table linens
Face towels
2nd washer - Tea towels
Kitchen hand towels
3rd washer - Pillow cases - 6
Sheets - 1
4th washer - Sheets - 2 to 4
Refill machine with sheets and white bed spreads until all have been washed.
5th washer - Bath towels
Wash cloths
White scrub cloths

6th washer - Colored scrub cloths
Dust cloths
Dust mops

Run the machine 5 to 10 minutes depending upon the efficiency of the machine and the soil on the clothes.

Drain a part of suds and add fresh hot water and soap as needed.

IV. Rinsing. As soon as the tub in which the clothes have been soaked is emptied, rinse the tub and fill three-fourths full of warm water.

Rinse clothes thoroughly in two waters by moving about in the water.

V. Wringing.

Sheets - Arrange wide hem of sheets in folds and run through wringer with warp threads running lengthwise.
Table Cloths - Arrange hem of table cloth in folds and run through wringer with warp threads running lengthwise.
Towels and dinner napkins through rinse water by folding once lengthwise.
Small napkins put through wringer straight.

Wring colored cloths by hand.
Wring dust mops by hand.

VI. Hanging. Wipe clothes lines with damp cloth.

Sheets - Hang right side out and hems down. Straighten selvedge and keep hems even.
Table Cloths - Hang straight, right side out and selvedges down. Straighten selvedge and keep the two even.
Pillow Cases - Hang one at a time with open end down.
Towels - Hang two together and straighten selvedges.
Napkins - Hang two together and straighten selvedges.

VII. Taking from line. Keep sorted.

. Fold sheets and table cloths evenly.
Take all towels of a kind off line and fold entire group together.

VIII. Sprinkle.

Table linens
Face towels (very slightly)
Pillow cases (very slightly)

IX. Ironing.

Group equipment and basket of clothes to save time and motions.

X. Put clothes away.

No standard laboratory test was found for checking the effect of laundering on the tensile strength of fabrics. The laboratory Fastness Test for Dyed or Printed cottons chosen to chéck the effect on the color of the fabrics of the two methods was Fastness Test (No. 2) of Group C-1. - Fastness to Domestic Washing, Laundering and Soaping (With Launder-Ometer).

This test as given in the 1931 Yearbook of the American Association of Textile Chemists and Colorists follows:

Enter sample to be tested into glass jar containing 100 c.c. of soap and soda solution heated to 160°F. Add 10 small rubber balls, then close jar tightly and place in Launder-Ometer which is half filled with water at 160°F. - rotate in machine for 30 minutes. Empty jar and rinse sample with 200 c.c. of water at 80°F. containing .05% acetic acid. Shake by hand and let stand 10 minutes. Empty and give a final rinse with 200 c.c. of cold water.

Hydroextract or wring and dry with a hot flat iron.

Soap Solution. 5 gms. of 88% neutral chip soap and 2 grams of soda ash per liter of water.

Three and one-sixth yards of each fabric were used for this study. One-sixth yard was removed and analyzed according to the methods set up by the American Society for Testing Materials (1930). The remainder was cut into one-yard lengths. Each yard of material was divided into eight sections by drawing threads through the fabric. Within each section, accurately measured, squares six by six inches were marked with India ink, parallel with the warp and filling yarns.

One-yard portions of each of these fabrics were laundered twenty times by the Manhattan Steam Laundry. The fabrics were entered in the regular bundle and washed as family work, and were ironed without starch, with the commercial ironer.

The two home management houses use the same laundry methods and a set of test portions of the fabrics was laundered alternately by them. Thus the materials were laundered twice a week, permitting completion of the problem in a sufficiently short period of time. These fabrics were dried out of doors part of the time and all

ironing was done with an electric hand iron.

The third test portions were laundered in the Launder-Ometer according to directions for Fastness Test No. 2. These specimens were dried in the laboratory and ironed lengthwise of the fabric with an electric hand iron.

One of the marked sections of each fabric was removed for test purposes after the first, second, third, fourth, fifth, tenth, fifteenth and twentieth launderings from the portions sent to the power laundry, from those sent to the home laundry and from those laundered in the laboratory.

Each of the sections removed after laundering were compared with the control to determine the amount of shrinkage. From the difference in the size of the six by six squares the shrinkage in inches per yard was calculated.

Each laundered section was then cut into strips, one and one-fourth inches wide and raveled to exactly one inch with the aid of the Lowenson Thread Counter. The tensile strength in pounds per strip was made with a Scott Power Tester. An average of five strips was taken for both warp and filling yarns, and reduced to pounds per single yarn. The difference in strength of the original fabric and the fabric after twenty launderings was used to determine the percentage loss in tensile strength.

The difference in color between the original fabric and the twentieth laundering specimen was measured by means of spectrophotometric analyses. A Bausch and Lomb spectrophotometer was used in which the standard was a magnesium carbonate block with an assumed reflection of 100 per cent at every wave length. The reflection of light from the specimen expressed in terms of density as compared with the standard was determined from the average of four readings made at intervals of 10 millimicrons, from 420 to 710 millimicrons. Graphs were made from these data and used as a means of comparing the effect of the laundry methods on the color of the fabrics.

INTERPRETATION OF DATA

An analyses of the fabrics chosen for this study show that although only broadcloths and chambrays were used these materials varied greatly in price and quality (Table I). The difference in the year purchased, no doubt, influenced the price. The tan broadcloth, tan and green chambrays were purchased in 1928; all others in 1932. Heavy and thin places were apparent in the chambray fabrics. A test of the variation of the tensile strength within these fabrics showed at least a three per cent deviation

Table I. Fabric Analyses of Materials

Fabric	Price per yard	Width in Inches	Conditioned weight in ounces per square yard	Thread count per inch		Tensile strength in pounds	
				W	F	W	F
Tan Chambray	0.25*	32	3.17	80	64	41.64	25.60
Green Chambray	0.25*	32	3.30	79	69	46.28	30.56
Tan Broadcloth	0.58*	36	2.66	96	88	35.24	27.74
Green Broadcloth	0.39	36	3.32	135	66	76.40	27.44
White Broadcloth	0.35	36	3.34	134	66	68.60	22.84
Blue Broadcloth	0.39	36	3.19	135	65	57.60	23.52

* Purchased in 1928.

from the mean for both the tan and green chambrays. This was proved to be true of the white and blue broadcloths also.

The effect of power and home launderings on these fabrics, expressed in terms of tensile strength, varied within wide limits as is indicated in Table VIII. Tables II to VII show the difficulties encountered in comparing the results of these tests. For example, the average tensile strength of the warp for the control of blue broadcloth was 57.60 pounds; the average tensile strength of the specimen after one laundering by the power laundry was 46.72 pounds and after twenty launderings was 63.20 pounds (Table II). The number of ends in these same specimens was 135 per inch for the control; 132 after the first laundering and 135 after the twentieth laundering. In an effort to overcome this irregularity the tensile strength was reduced to a single strand basis by dividing the strength per strip by the number of threads per inch.

The tensile strength per single strand for the first, second and third laundered specimens showed a loss in strength; all other specimens gained in strength. The tenth laundered specimen had the smallest number of ends per inch and a large tensile strength per strip. This

resulted in the greatest strength per single strand, which indicates a place in the fabric where the warp yarns were stronger than the average.

This wide difference that occurred between the launderings of blue broadcloth was, no doubt, partly due to the variation within the fabric itself, which amounted to four per cent deviation from the average.

The twentieth laundering of this group laundered by the power method increased in strength 9.6 per cent in the warp and lost 10.50 per cent in the filling.

The specimens of blue broadcloth laundered by the home laundry and laboratory methods showed a similar variation between launderings. The effect of the home method on this fabric for twenty launderings was a loss of 3.98 per cent for the warp and 4.97 per cent for the filling; that of the laboratory method was a gain of 6.78 per cent for the warp and 11.60 per cent for the filling.

There was as great a variation in the effect of the power and home laundry methods on the tan chambray as on the blue broadcloth. The power laundry caused a loss of 15.30 per cent in the warp of tan chambray as compared with a loss of only 1.80 per cent for the home laundry method. In the filling strips this position was reversed, the power

Table II. Tensile Strength of Tan Chambray Specimens

Control	Warp	Filling
Av. thread count per in.	80	64
Tensile strength in lbs.	41.80	23.60
	42.60	24.80
	41.00	27.40
	40.80	25.80
	42.00	27.40
Av. tensile strength	41.64	25.80
Av. single thread	0.52	0.40

	Power		Home		Laboratory	
	Warp	Filling	Warp	Filling	Warp	Filling
FIRST LAUNDERING						
Av. thread count per in.	80	65	79	66	80	66
Tensile strength in lbs.	34.80	28.00	39.00	27.00	39.60	25.20
	35.60	25.80	37.80	28.80	38.20	25.40
	34.20	23.20	36.80	26.10	39.40	26.60
	34.00	29.20	37.40	26.00	37.80	25.40
	34.20	28.80	36.30	29.00	41.80	25.90
Av. tensile strength	34.56	27.00	37.46	27.38	38.96	25.90
Av. single thread	0.43	0.42	0.47	0.42	0.49	0.39
SECOND LAUNDERING						
Av. thread count per in.	78	67	82	62	86	64
Tensile strength in lbs.	35.40	26.60	41.00	26.00	42.00	26.40
	38.80	27.80	42.00	27.00	36.80	25.40
	40.00	28.20	44.00	27.00	35.40	24.80
	37.80	25.80	40.00	26.80	37.40	26.90
	38.40	26.20	41.00	26.80	37.00	27.00
Av. tensile strength	37.88	26.72	41.60	26.72	37.72	26.10
Av. single thread	0.49	0.40	0.51	0.43	0.44	0.41
THIRD LAUNDERING						
Av. thread count per in.	77	68	80	67	79	66
Tensile strength in lbs.	34.00	26.40	39.00	26.40	39.00	25.40
	34.00	28.00	42.00	27.80	40.00	26.40
	35.60	27.60	41.00	26.60	37.80	26.80
	33.00	28.80	40.00	26.40	35.80	25.00
	34.80	27.00	42.00	27.20	38.20	25.90
Av. tensile strength	37.28	27.72	40.80	26.88	38.16	25.90
Av. single thread	0.48	0.41	0.51	0.40	0.49	0.39
FOURTH LAUNDERING						
Av. thread count per in.	81	67	80	67	79	68
Tensile strength in lbs.	37.00	29.80	41.00	26.20	37.80	26.90
	26.80	30.40	42.00	30.00	40.60	26.90
	35.10	28.40	41.00	27.00	31.00	26.40
	38.60	27.20	40.00	27.00	32.60	26.90
	37.00	26.00	37.00	28.00	34.90	30.00
Av. tensile strength	34.90	28.36	40.20	27.64	35.38	27.42
Av. single thread	0.43	0.42	0.50	0.41	0.45	0.43
FIFTH LAUNDERING						
Av. thread count per in.	81	72	81	69	83	66
Tensile strength in lbs.	37.00	27.80	39.00	26.40	39.00	25.80
	37.40	24.60	40.00	26.60	41.00	26.80
	33.60	28.00	39.00	26.40	41.00	25.00
	35.00	27.80	38.00	25.00	40.20	30.00
	38.80	26.00	39.00	26.80	38.00	22.80
Av. tensile strength	36.36	26.84	39.00	26.24	39.84	26.08
Av. single thread	0.45	0.37	0.49	0.38	0.48	0.40
TENTH LAUNDERING						
Av. thread count per in.	76	73	81	68	81	67
Tensile strength in lbs.	33.40	30.60	32.40	26.00	40.00	26.80
	31.20	30.40	36.00	25.00	36.40	25.40
	27.80	27.80	30.20	24.00	38.00	30.80
	33.00	26.00	33.60	24.80	37.00	27.00
	32.00	28.00	32.40	26.60	35.40	26.80
Av. tensile strength	31.68	28.56	32.92	25.28	37.36	27.36
Av. single thread	0.42	0.39	0.46	0.37	0.46	0.41
FIFTEENTH LAUNDERING						
Av. thread count per in.	80	70	81	69	83	65
Tensile strength in lbs.	34.00	27.00	32.20	24.40	39.00	28.80
	37.00	24.00	35.40	27.40	42.00	32.50
	35.80	23.80	35.40	26.40	40.20	25.90
	28.40	28.40	31.00	28.40	40.60	30.40
	36.40	28.40	34.60	26.80	33.60	26.20
Av. tensile strength	34.52	26.32	35.72	26.68	37.08	28.76
Av. single thread	0.43	0.38	0.44	0.39	0.45	0.44
TWENTIETH LAUNDERING						
Av. thread count per in.	81	65	80	69	81	68
Tensile strength in lbs.	35.00	26.40	34.60	26.40	42.40	30.80
	36.20	23.20	35.80	25.40	41.00	29.80
	33.00	27.20	31.60	23.80	37.80	26.40
	36.40	26.00	36.40	25.90	40.00	27.40
	36.80	26.00	32.80	22.80	36.40	25.60
Av. tensile strength	35.48	25.76	34.24	24.86	39.52	28.00
Av. single thread	0.44	0.40	0.43	0.36	0.49	0.41
Percentage loss in tensile strength	15.80	1.48	17.80	10.67	6.15	-2.24

Table III. Tensile Strength of Green Chambray Specimens

Control	Warp	Filling
Av. thread count per in.	85	69
Tensile strength in lbs.	46.20	29.40
	45.60	29.60
	46.00	32.00
	47.00	30.00
	46.60	31.80
Av. tensile strength	46.28	30.56
Av. single thread	0.55	0.44

	Power		Home		Laboratory	
	Warp	Filling	Warp	Filling	Warp	Filling
FIRST LAUNDERING						
Av. thread count per in.	79	71	79	75	85	74
Tensile strength in lbs.	43.60	31.60	39.00	30.60	45.40	27.60
	43.40	32.20	40.80	30.40	42.00	27.00
	40.00	32.20	40.00	30.90	42.00	33.00
	43.40	32.00	41.20	31.00	37.40	33.20
	44.00	33.60	39.60	30.00	43.80	34.00
Av. tensile strength	42.88	32.32	40.12	30.58	42.12	30.96
Av. single thread	0.53	0.44	0.51	0.41	0.50	0.42
SECOND LAUNDERING						
Av. thread count per in.	85	72	81	72	83	71
Tensile strength in lbs.	43.00	26.20	42.00	29.00	41.80	27.00
	43.00	32.20	45.00	32.00	43.00	26.90
	43.20	34.60	42.00	29.80	41.80	26.60
	44.00	34.80	39.00	26.60	38.00	26.80
	45.40	34.00	41.00	28.00	40.80	26.40
Av. tensile strength	43.72	32.36	43.80	29.08	41.08	26.74
Av. single thread	0.51	0.45	0.54	0.40	0.50	0.38
THIRD LAUNDERING						
Av. thread count per in.	78	77	79	74	82	73
Tensile strength in lbs.	42.40	35.00	39.00	27.00	41.60	30.20
	42.00	33.80	41.00	26.80	44.40	33.20
	41.40	35.40	39.00	26.80	37.00	32.40
	40.80	34.80	40.00	26.40	41.60	32.20
	41.00	26.00	41.00	26.40	41.00	32.20
Av. tensile strength	41.52	33.00	40.00	26.68	41.12	32.04
Av. single thread	0.53	0.43	0.51	0.36	0.50	0.44
FOURTH LAUNDERING						
Av. thread count per in.	81	75	81	74	81	74
Tensile strength in lbs.	41.00	35.20	41.00	24.60	38.00	27.40
	44.20	32.60	42.00	30.00	38.40	26.80
	42.00	33.60	41.00	27.00	39.00	26.40
	41.00	34.20	40.00	26.80	35.00	26.60
	42.20	32.40	38.00	26.80	38.00	27.00
Av. tensile strength	42.08	53.66	40.40	27.04	39.68	26.84
Av. single thread	0.52	0.72	0.50	0.37	0.49	0.36
FIFTH LAUNDERING						
Av. thread count per in.	77	73	81	74	80	73
Tensile strength in lbs.	38.00	31.80	44.00	26.80	40.60	33.40
	40.00	32.00	44.00	26.40	39.40	32.30
	40.40	28.40	45.00	27.40	39.00	30.20
	39.80	33.00	40.00	26.60	36.20	31.40
	39.40	32.40	41.00	25.40	40.40	27.40
Av. tensile strength	39.52	31.54	42.80	26.25	39.12	30.92
Av. single thread	0.50	0.43	0.53	0.36	0.49	0.42
TENTH LAUNDERING						
Av. thread count per in.	78	77	83	73	83	74
Tensile strength in lbs.	42.00	32.40	32.00	26.60	38.00	27.00
	40.60	34.00	37.80	25.00	40.60	26.40
	37.60	33.00	37.60	25.40	37.40	26.40
	36.80	33.40	34.00	23.00	38.40	26.60
	37.40	28.60	34.90	26.40	39.00	26.60
Av. tensile strength	38.88	32.28	35.26	25.28	38.68	26.60
Av. single thread	0.50	0.42	0.43	0.34	0.47	0.36
FIFTEENTH LAUNDERING						
Av. thread count per in.	82	77	83	75	83	71
Tensile strength in lbs.	41.80	32.00	38.00	25.60	42.80	30.20
	37.20	31.00	40.60	24.80	43.60	31.00
	36.80	31.80	35.20	28.60	39.00	30.60
	32.40	31.20	37.20	26.40	39.00	30.40
	40.40	28.00	39.60	27.00	42.40	32.40
Av. tensile strength	37.72	30.80	38.12	26.48	41.36	30.92
Av. single thread	0.46	0.40	0.46	0.35	0.50	0.44
TWENTIETH LAUNDERING						
Av. thread count per in.	82	75	83	74	82	72
Tensile strength in lbs.	38.60	33.00	35.40	26.00	39.00	29.80
	38.40	31.00	36.40	24.80	42.00	31.80
	40.30	31.60	35.40	25.00	40.00	31.40
	38.60	31.40	37.80	22.60	38.90	32.80
	38.60	31.40	35.60	25.40	39.80	31.00
Av. tensile strength	38.90	31.68	36.12	24.76	39.94	31.36
Av. single thread	0.47	0.42	0.44	0.34	0.49	0.44
Percentage loss in tensile strength	13.02	2.48	20.20	24.30	10.64	1.80

Table IV. Tensile Strength of Tan Broadcloth Specimens

Control	Warp	Filling
Av. thread count per in.	96	88
Tensile strength in lbs.	35.60	23.00
	35.80	28.40
	30.00	31.20
	38.60	31.10
	36.20	27.00
Av. tensile strength	35.24	27.74
Av. single thread	0.37	0.32

	Power		Home		Laboratory	
	Warp	Filling	Warp	Filling	Warp	Filling
FIRST LAUNDERING						
Av. thread count per in.	100	90	103	90	112	87
Tensile strength in lbs.	35.20	31.00	32.80	28.80	36.60	27.00
	34.40	27.00	35.00	28.60	35.00	27.20
	33.20	24.00	34.00	27.40	37.40	27.40
	33.60	31.20	35.00	24.80	37.00	24.80
	34.00	27.40	35.60	25.80	34.40	26.60
Av. tensile strength	34.08	28.12	34.48	27.08	36.08	26.60
Av. single thread	0.34	0.31	0.34	0.30	0.32	0.32
SECOND LAUNDERING						
Av. thread count per in.	103	91	108	90	109	91
Tensile strength in lbs.	24.60	24.00	39.00	27.60	34.60	26.60
	23.20	27.20	38.00	30.40	35.00	30.40
	33.20	27.60	36.00	26.40	39.40	27.00
	32.40	26.40	39.00	28.00	37.40	25.90
	32.80	27.40	37.00	26.80	35.20	20.60
Av. tensile strength	29.24	26.52	37.80	27.84	36.52	26.10
Av. single thread	0.28	0.29	0.35	0.31	0.33	0.29
THIRD LAUNDERING						
Av. thread count per in.	101	92	104	87	103	87
Tensile strength in lbs.	35.00	28.80	42.00	27.40	35.20	30.20
	32.00	33.00	41.00	25.20	34.90	26.60
	35.60	31.00	39.00	29.20	35.00	31.00
	33.80	27.00	38.00	27.40	36.00	24.80
	33.40	29.00	38.00	31.00	37.00	26.40
Av. tensile strength	33.96	29.96	39.60	28.04	35.62	29.80
Av. single thread	0.33	0.33	0.38	0.32	0.35	0.34
FOURTH LAUNDERING						
Av. thread count per in.	100	92	107	91	108	91
Tensile strength in lbs.	34.40	21.00	44.00	31.60	35.80	26.60
	36.00	29.00	32.00	30.60	37.90	26.80
	35.40	31.00	41.00	24.00	32.00	20.00
	35.00	31.20	36.00	31.40	36.80	26.60
	37.40	28.00	42.00	27.60	32.60	24.40
Av. tensile strength	35.64	28.04	39.00	29.04	35.02	25.28
Av. single thread	0.36	0.31	0.37	0.32	0.32	0.27
FIFTH LAUNDERING						
Av. thread count per in.	99	93	108	88	108	100
Tensile strength in lbs.	33.00	28.00	42.00	27.00	35.60	29.00
	34.60	28.40	36.00	28.80	36.40	31.40
	32.80	28.60	36.00	26.50	34.60	26.00
	33.00	27.40	38.00	29.00	33.00	25.00
	31.40	27.60	36.00	25.40	35.40	25.00
Av. tensile strength	32.96	28.00	37.60	26.34	35.00	27.28
Av. single thread	0.33	0.30	0.35	0.30	0.32	0.27
TENTH LAUNDERING						
Av. thread count per in.	94	93	100	97	103	91
Tensile strength in lbs.	33.60	29.60	32.00	26.00	35.40	26.80
	32.30	28.40	27.40	24.00	36.80	25.90
	29.00	26.80	31.40	23.00	33.60	25.90
	29.80	26.00	33.40	27.00	32.00	25.60
	31.60	29.80	30.80	25.00	35.90	26.60
Av. tensile strength	31.26	27.92	31.00	25.00	34.74	26.16
Av. single thread	0.33	0.30	0.31	0.26	0.34	0.28
FIFTEENTH LAUNDERING						
Av. thread count per in.	108	91	105	90	111	90
Tensile strength in lbs.	32.00	26.80	28.40	28.20	34.00	29.80
	32.00	22.80	33.40	26.20	36.60	31.40
	32.00	27.80	30.60	26.40	35.20	27.00
	28.80	29.00	30.20	29.20	38.60	31.80
	29.00	28.00	32.40	26.00	36.00	31.60
Av. tensile strength	30.76	26.88	31.40	27.00	36.08	30.52
Av. single thread	0.29	0.30	0.30	0.30	0.33	0.34
TWENTIETH LAUNDERING						
Av. thread count per in.	110	91	105	93	100	90
Tensile strength in lbs.	28.80	26.60	30.40	24.20	30.00	21.00
	33.80	28.60	32.20	27.60	34.6	33.00
	30.20	26.80	32.90	24.00	34.40	31.60
	29.80	28.00	32.60	26.40	36.00	31.00
	32.00	28.00	34.40	28.40	37.00	31.00
Av. tensile strength	30.92	27.60	32.50	26.12	34.40	29.52
Av. single thread	0.27	0.30	0.31	0.28	0.34	0.33
Percentage loss in tensile strength	24.00	4.00	16.00	11.00	7.00	-4.00

Table V. Tensile Strength of Green Broadcloth Specimens

Control	Warp	Filling
Av. thread count per in.	135	66
Tensile strength in lbs.	78.00	26.60
	69.00	26.00
	77.00	27.80
	78.00	29.40
	80.00	27.40
Av. tensile strength	76.40	27.44
Av. single thread	0.57	0.42

	Power		Home		Laboratory	
	Warp	Filling	Warp	Filling	Warp	Filling
FIRST LAUNDERING						
Av. thread count per in.	128	66	135	68	131	68
Tensile strength in lbs.	72.00	30.20	87.00	28.80	70.00	27.00
	78.00	30.00	84.00	28.60	70.00	27.00
	60.00	31.60	83.00	27.60	65.00	31.80
	71.00	28.60	79.00	29.40	63.00	26.90
	77.00	27.40	76.80	23.00	67.00	27.00
Av. tensile strength	71.60	29.56	81.96	27.48	67.00	27.94
Av. single thread	0.56	0.45	0.61	0.40	0.51	0.41
SECOND LAUNDERING						
Av. thread count per in.	132	68	136	69	135	69
Tensile strength in lbs.	72.00	27.80	80.00	28.80	72.00	32.40
	74.00	28.00	80.50	27.40	70.00	26.80
	76.00	27.80	70.00	30.20	68.00	27.90
	71.00	29.00	71.00	34.00	62.00	26.40
	76.00	28.00	78.00	27.80	72.00	26.80
Av. tensile strength	73.80	28.30	75.90	29.64	68.80	28.06
Av. single thread	0.56	0.42	0.56	0.43	0.51	0.40
THIRD LAUNDERING						
Av. thread count per in.	135	68	135	69	131	67
Tensile strength in lbs.	80.00	34.80	80.00	32.00	62.00	33.00
	82.00	34.00	78.00	36.50	65.00	31.40
	84.00	34.20	79.00	32.00	56.00	26.80
	80.00	33.31	78.00	31.90	64.00	30.60
	80.00	33.10	82.00	32.90	40.00	30.60
Av. tensile strength	81.20	33.88	79.40	33.26	57.40	30.48
Av. single thread	0.60	0.50	0.59	0.48	0.44	0.46
FOURTH LAUNDERING						
Av. thread count per in.	133	69	135	68	138	78
Tensile strength in lbs.	70.00	32.60	73.00	31.40	70.00	32.20
	77.00	33.40	78.00	33.90	74.00	30.60
	72.00	34.80	73.00	34.00	74.00	36.20
	79.00	33.80	65.00	31.00	70.00	32.90
	82.00	35.00	74.00	31.40	68.00	33.20
Av. tensile strength	76.00	33.92	72.60	32.34	71.20	33.02
Av. single thread	0.57	0.49	0.54	0.48	0.52	0.42
FIFTH LAUNDERING						
Av. thread count per in.	138	71	136	68	138	70
Tensile strength in lbs.	78.00	25.40	85.00	27.00	57.00	27.00
	69.00	31.00	74.00	27.20	63.00	32.60
	77.00	29.00	79.00	29.00	64.00	26.60
	65.00	28.80	72.00	27.00	64.00	27.40
	69.00	27.80	72.00	28.20	69.00	26.60
Av. tensile strength	71.60	28.40	76.60	27.68	63.40	28.04
Av. single thread	0.51	0.40	0.56	0.41	0.46	0.40
TENTH LAUNDERING						
Av. thread count per in.	130	69	140	73	133	69
Tensile strength in lbs.	59.00	30.00	58.00	28.60	62.00	27.40
	66.00	32.20	57.00	30.60	64.00	27.60
	64.80	32.40	63.00	31.00	63.00	33.80
	53.00	25.80	63.00	29.40	69.00	30.40
	63.00	31.60	68.00	33.80	70.00	27.00
Av. tensile strength	61.16	30.40	61.80	30.68	65.60	29.24
Av. single thread	0.47	0.44	0.44	0.42	0.49	0.42
FIFTEENTH LAUNDERING						
Av. thread count per in.	133	70	133	70	138	70
Tensile strength in lbs.	71.00	31.80	70.00	30.00	84.00	33.60
	58.00	31.20	77.00	31.40	82.00	30.80
	81.00	28.80	52.00	33.00	75.00	32.60
	57.00	30.40	64.00	27.80	68.00	32.40
	72.00	27.80	75.00	27.80	80.00	29.20
Av. tensile strength	67.80	30.04	67.60	30.00	77.80	31.72
Av. single thread	0.51	0.43	0.51	0.43	0.56	0.45
TWENTIETH LAUNDERING						
Av. thread count per in.	133	67	133	69	133	69
Tensile strength in lbs.	65.00	26.40	78.00	34.80	73.00	30.40
	72.00	27.40	64.00	29.00	73.00	27.60
	76.00	31.60	69.00	31.60	80.00	34.80
	76.00	27.40	71.00	32.40	78.00	31.60
	69.00	32.00	69.00	31.00	83.00	30.60
Av. tensile strength	71.60	28.96	70.20	31.76	77.40	31.00
Av. single thread	0.54	0.43	0.53	0.46	0.58	0.45
Percentage loss in tensile strength	4.70	-4.09	6.88	-9.80	-2.65	-11.19

Table VI. Tensile Strength of White Broadcloth Specimens

Control	Warp	Filling
Av. thread count per in.	134	66
Tensile strength in lbs.	63.00	20.00
	73.00	22.60
	71.00	23.60
	68.00	25.00
	68.00	23.00
Av. tensile strength	68.60	22.84
Av. single thread	0.51	0.35

	Power		Home		Laboratory	
	Warp	Filling	Warp	Filling	Warp	Filling
FIRST LAUNDERING						
Av. thread count per in.	135	69	135	69	136	69
Tensile strength in lbs.	75.00	27.80	73.00	23.00	76.00	26.60
	69.00	29.00	75.00	25.00	67.00	27.00
	72.00	31.60	74.00	24.00	62.00	31.20
	58.00	31.20	72.00	26.00	61.00	27.00
	58.00	27.00	64.00	23.60	57.00	26.40
Av. tensile strength	66.40	29.32	71.60	24.32	64.60	27.64
Av. single thread	0.49	0.43	0.53	0.35	0.48	0.40
SECOND LAUNDERING						
Av. thread count per in.	137	70	137	67	139	67
Tensile strength in lbs.	71.00	27.60	68.00	23.00	70.00	23.00
	67.00	30.60	65.00	26.00	66.00	26.00
	56.00	28.60	64.00	24.00	55.00	25.50
	68.00	30.00	64.00	22.00	68.00	24.00
	44.00	24.60	71.00	20.00	68.00	28.40
Av. tensile strength	61.20	28.68	66.40	23.00	65.40	25.38
Av. single thread	0.45	0.40	0.49	0.34	0.47	0.38
THIRD LAUNDERING						
Av. thread count per in.	133	73	138	67	137	68
Tensile strength in lbs.	62.00	31.00	75.00	21.00	45.00	30.60
	67.00	29.80	79.00	20.00	73.00	27.40
	67.00	29.20	70.00	29.00	69.00	27.40
	40.00	29.60	67.00	25.00	70.00	26.40
	66.00	27.60	66.00	25.00	58.00	25.80
Av. tensile strength	60.40	29.44	71.40	24.00	63.00	27.60
Av. single thread	0.45	0.40	0.52	0.36	0.46	0.41
FOURTH LAUNDERING						
Av. thread count per in.	134	70	139	68	134	68
Tensile strength in lbs.	65.00	25.40	61.00	25.40	55.00	26.60
	47.00	30.00	75.00	25.60	59.00	27.00
	65.00	28.80	70.00	27.00	59.00	24.00
	62.00	27.00	63.00	25.20	66.00	29.00
	48.00	27.00	64.00	26.40	63.00	31.40
Av. tensile strength	57.40	27.64	66.60	25.92	60.40	27.60
Av. single thread	0.43	0.40	0.48	0.38	0.45	0.41
FIFTH LAUNDERING						
Av. thread count per in.	132	70	137	72	138	66
Tensile strength in lbs.	67.00	26.60	69.00	26.00	61.00	25.20
	65.00	24.80	75.00	26.80	55.00	26.80
	59.00	24.60	70.00	26.40	65.00	26.40
	54.00	25.60	52.00	25.00	69.00	26.60
	62.00	24.80	72.00	23.00	62.00	26.80
Av. tensile strength	61.40	25.48	67.60	25.44	62.40	26.36
Av. single thread	0.47	0.32	0.49	0.35	0.46	0.40
TENTH LAUNDERING						
Av. thread count per in.	135	70	139	67	140	66
Tensile strength in lbs.	64.00	28.00	65.00	22.00	70.00	24.60
	65.00	26.00	63.00	26.40	69.00	25.30
	66.00	23.60	52.00	29.40	61.00	25.80
	64.90	25.40	52.00	26.00	61.00	26.40
	64.00	28.80	57.00	29.90	57.00	25.90
Av. tensile strength	64.78	26.36	57.80	26.74	63.60	25.60
Av. single thread	0.48	0.38	0.42	0.40	0.45	0.39
FIFTEENTH LAUNDERING						
Av. thread count per in.	136	69	140	64	138	66
Tensile strength in lbs.	67.00	25.60	66.00	27.90	69.00	26.80
	64.00	26.60	59.00	27.60	75.00	29.00
	65.00	25.80	72.00	26.80	72.00	29.40
	67.00	24.80	69.00	27.00	78.00	30.40
	65.00	23.00	72.00	27.40	67.00	26.60
Av. tensile strength	65.60	25.16	67.60	27.34	72.20	28.24
Av. single thread	0.47	0.37	0.48	0.43	0.52	0.43
TWENTIETH LAUNDERING						
Av. thread count per in.	135	71	137	70	140	66
Tensile strength in lbs.	65.00	27.40	68.00	27.40	64.00	32.20
	63.00	24.30	61.00	24.40	72.00	31.00
	68.00	24.00	60.00	25.40	68.00	30.20
	63.00	23.20	71.00	28.20	69.00	30.80
	55.00	27.40	69.00	25.40	72.00	27.90
Av. tensile strength	62.80	25.30	65.80	26.16	69.00	30.42
Av. single thread	0.47	0.36	0.48	0.37	0.49	0.46
Percentage loss in tensile strength	9.00	-3.00	6.00	-8.00	4.00	-33.00

Table VII. Tensile Strength of Blue Broadcloth Specimens

Control	Warp	Filling
Av. thread count per in.	135	65
Tensile strength in lbs.	49.00	24.00
	59.00	25.00
	57.00	22.00
	62.00	22.80
	61.00	23.80
Av. tensile strength	57.60	23.52
Av. single thread	0.43	0.36

	Power		Home		Laboratory	
	Warp	Filling	Warp	Filling	Warp	Filling
FIRST LAUNDERING						
Av. thread count per in.	132	62	132	67	139	66
Tensile strength in lbs.	44.00	23.00	59.00	22.00	46.00	24.80
	45.20	24.40	63.00	25.00	63.00	24.80
	46.20	22.40	55.00	22.60	54.00	27.60
	46.60	26.80	61.00	21.40	44.00	24.20
	45.60	24.00	65.00	23.80	45.00	25.60
Av. tensile strength	46.72	24.12	60.60	23.04	50.40	25.40
Av. single thread	0.35	0.39	0.46	0.34	0.36	0.39
SECOND LAUNDERING						
Av. thread count per in.	134	67	135	68	136	68
Tensile strength in lbs.	45.20	22.00	65.00	20.00	52.00	25.40
	33.20	23.80	65.00	23.00	40.00	26.40
	43.40	23.00	68.00	20.00	40.00	26.00
	45.60	23.00	63.00	21.00	55.00	27.00
	45.60	24.60	64.00	22.00	44.00	26.80
Av. tensile strength	44.60	23.28	65.00	21.20	46.20	26.32
Av. single thread	0.33	0.35	0.48	0.31	0.34	0.39
THIRD LAUNDERING						
Av. thread count per in.	140	67	132	68	137	68
Tensile strength in lbs.	46.60	26.20	63.00	23.00	59.00	26.20
	47.00	28.00	66.00	25.00	42.00	26.80
	46.00	29.00	59.00	21.00	52.00	26.80
	48.80	29.00	65.00	26.00	50.00	27.00
	46.40	25.60	67.00	26.00	40.00	27.00
Av. tensile strength	46.56	27.56	64.00	24.20	48.60	26.76
Av. single thread	0.33	0.41	0.49	0.36	0.36	0.39
FOURTH LAUNDERING						
Av. thread count per in.	134	71	130	68	131	68
Tensile strength in lbs.	61.00	26.20	58.00	32.00	46.00	27.00
	66.00	27.20	56.00	29.00	42.00	27.00
	60.00	26.80	63.00	27.00	51.00	26.40
	60.00	26.60	66.00	23.00	49.00	30.00
	60.00	25.80	55.00	20.00	42.00	25.40
Av. tensile strength	61.20	26.52	59.60	26.20	46.00	27.16
Av. single thread	0.46	0.37	0.46	0.39	0.35	0.40
FIFTH LAUNDERING						
Av. thread count per in.	132	67	134	67	137	66
Tensile strength in lbs.	60.00	22.20	56.00	25.00	67.00	26.30
	60.00	22.60	57.00	23.00	58.00	26.00
	53.00	24.40	45.00	23.00	36.00	26.40
	65.00	24.60	63.00	30.00	63.00	26.00
	52.00	23.40	55.00	29.00	63.00	26.60
Av. tensile strength	58.00	23.44	55.20	26.00	57.40	26.26
Av. single thread	0.44	0.35	0.41	0.39	0.42	0.60
TENTH LAUNDERING						
Av. thread count per in.	128	67	134	69	135	67
Tensile strength in lbs.	62.00	23.00	42.00	22.00	49.00	23.80
	58.00	24.40	41.00	25.00	52.00	26.60
	63.00	24.60	40.00	25.80	53.00	27.00
	59.00	25.00	50.00	26.00	47.00	25.80
	53.00	24.40	45.00	24.00	47.00	26.40
Av. tensile strength	59.00	24.28	43.60	24.56	49.60	25.92
Av. single thread	0.62	0.36	0.33	0.36	0.37	0.39
FIFTEENTH LAUNDERING						
Av. thread count per in.	133	70	134	69	132	67
Tensile strength in lbs.	60.00	21.40	52.00	25.80	65.00	26.40
	59.00	22.20	67.00	27.00	62.00	26.90
	54.00	21.00	63.00	25.00	69.00	28.00
	57.00	20.80	62.00	27.60	66.00	29.40
	58.00	21.00	66.00	28.20	67.00	24.20
Av. tensile strength	57.60	21.28	62.00	26.72	65.80	26.98
Av. single thread	0.43	0.30	0.46	0.39	0.50	0.40
TWENTIETH LAUNDERING						
Av. thread count per in.	135	68	133	69	135	67
Tensile strength in lbs.	65.00	23.60	49.00	27.90	54.00	27.00
	68.00	20.40	58.00	30.20	63.00	26.20
	64.00	20.80	60.00	27.00	50.00	26.40
	59.00	22.20	51.00	24.00	70.00	28.40
	60.00	23.00	54.00	21.80	70.00	27.20
Av. tensile strength	63.20	22.00	54.50	26.18	61.40	27.04
Av. single thread	0.47	0.32	0.41	0.38	0.46	0.40
Percentage loss in tensile strength	-9.60	10.50	3.98	-4.97	-6.78	-11.60

Table VIII. Tensile Strength of Control and Twentieth Laundering Specimens in Pounds Per Single Thread

	Tan Chambray		Green Chambray		Tan Broadcloth		Green Broadcloth		White Broadcloth		Blue Broadcloth	
	W	F	W	F	W	F	W	F	W	F	W	F
Control	0.52	0.40	0.56	0.44	0.37	0.32	0.57	0.40	0.51	0.35	0.43	0.36
Power	0.42	0.40	0.48	0.42	0.28	0.30	0.54	0.44	0.42	0.36	0.47	0.32
Home	0.43	0.36	0.44	0.34	0.31	0.28	0.53	0.46	0.50	0.37	0.41	0.38
Laboratory	0.49	0.41	0.49	0.44	0.34	0.33	0.59	0.45	0.50	0.46	0.46	0.41

Table IX. Percentage Loss in Tensile Strength of Twentieth Laundering Specimens

Method	Tan Chambray		Green Chambray		Tan Broadcloth		Green Broadcloth		White Broadcloth		Blue Broadcloth	
	W	F	W	F	W	F	W	F	W	F	W	F
Power	15.80	1.50	13.02	2.48	23.64	3.80	4.70	-4.09	9.17	-2.87	-9.60	10.50
Home	17.80	10.67	20.20	24.30	15.74	10.80	6.88	-9.80	6.21	-7.80	3.98	-4.97
Laboratory	6.15	-2.24	10.64	1.80	6.52	-4.12	-2.65	-8.19	3.52	-3.32	-6.78	-11.60

laundry causing only a 1.50 per cent loss and the home laundry method resulting in a loss of 10.67 per cent. In all other cases there was a more consistent loss or gain as a result of both laundry methods.

The percentage loss in strength of the twentieth laundering of all fabrics showed that in eight of the twelve tests run those laundered in the home had lost more strength than those laundered by the power method. Grouping the warp and filling for both methods, in six specimens the materials gained in strength over the control and in nine specimens the loss in tensile strength was more than ten per cent for twenty launderings. Of these, four specimens were laundered by the power laundry and six by the home laundry.

In the laboratory test, in six of the twelve specimens there was a gain in strength for the twentieth laundering.

Spectrophotometric Analyses of Fabrics

Both the power and home laundries caused some change in the color of all fabrics used in this test. Some fabrics lost color, some changed hue, and others became darker as the result of graying. The lowering of the lines in the color curve as shown in Fig. 2 indicates a loss of color;

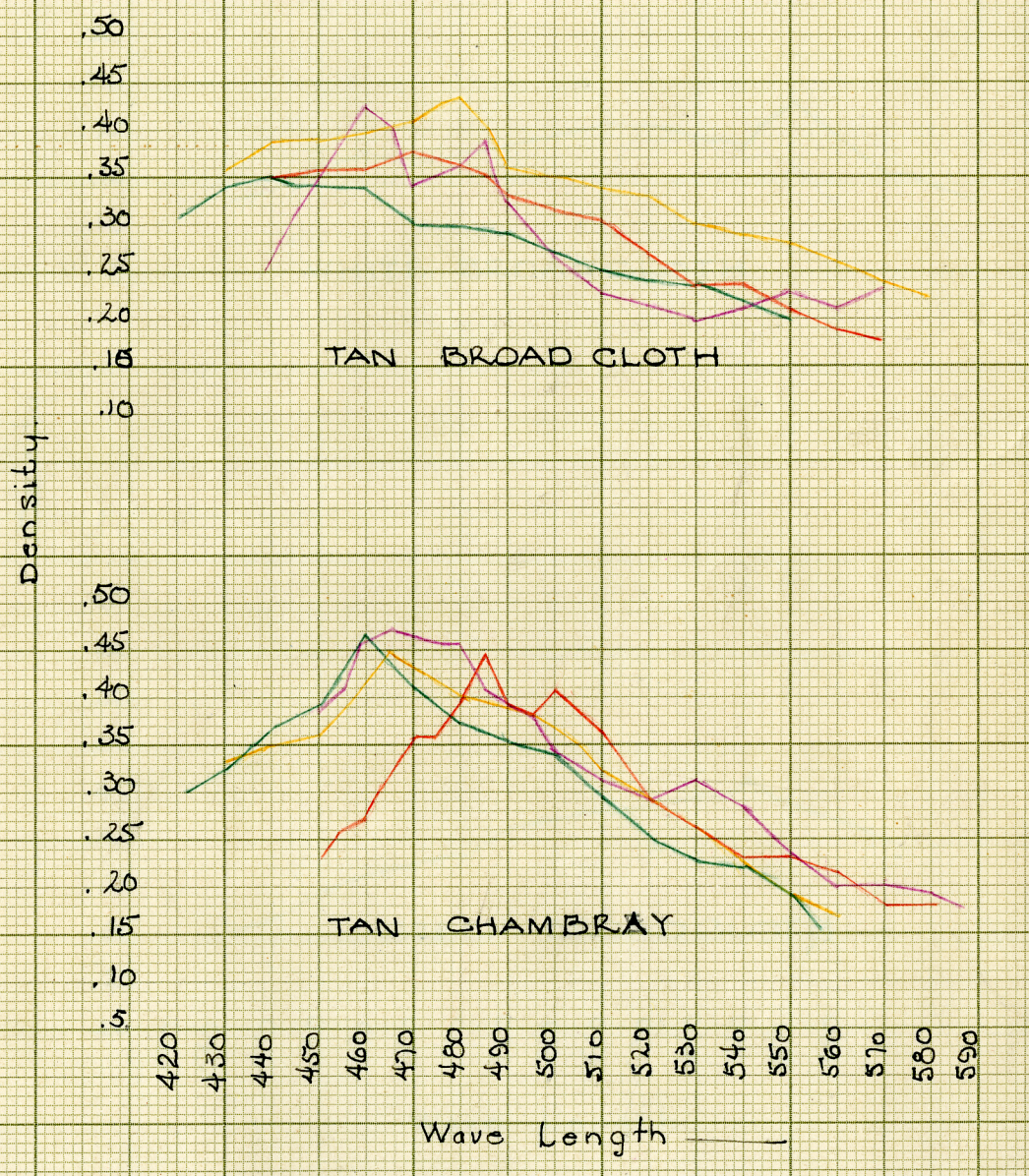


FIG 1. COLOR CHANGE IN FABRIC

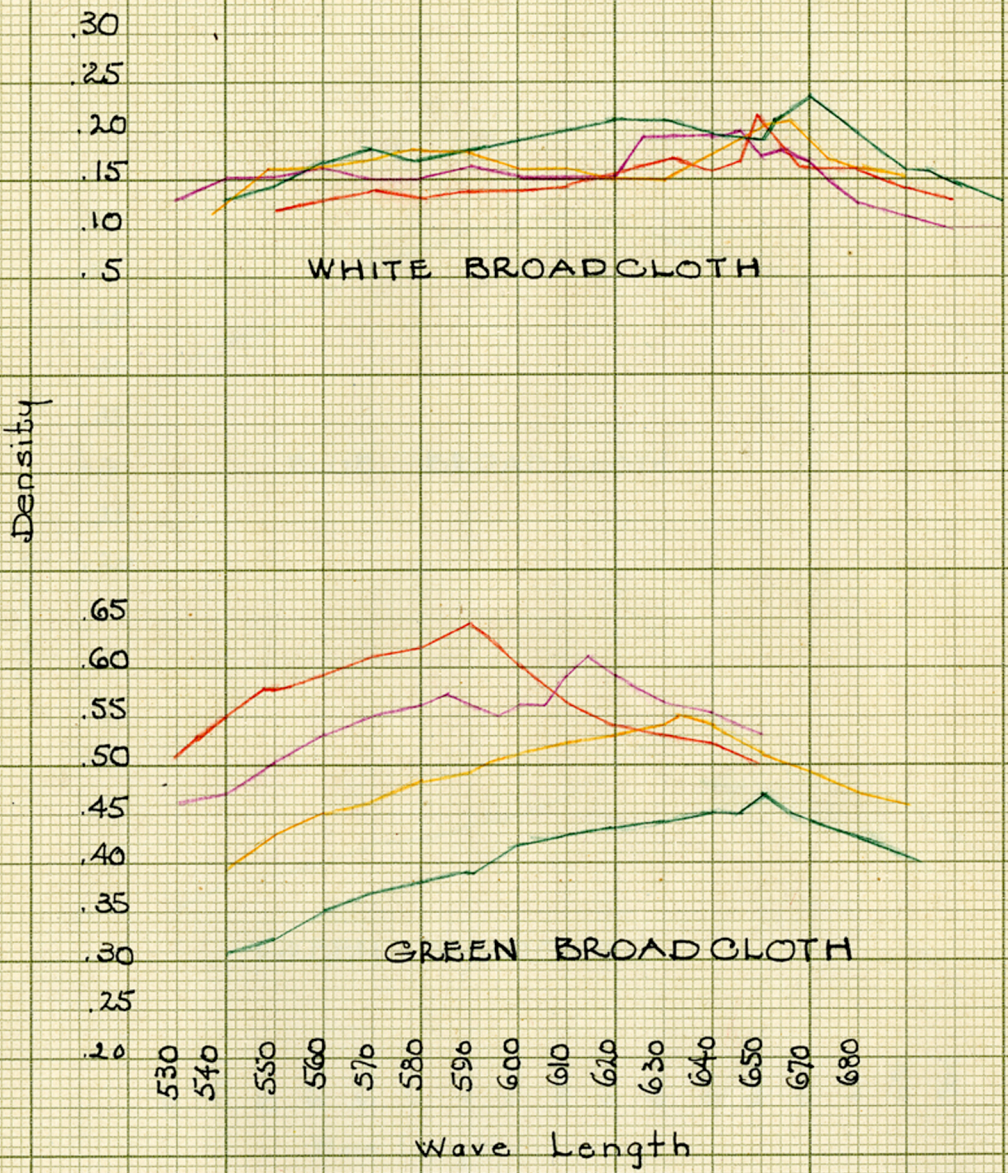


FIG. 2 - COLOR CHANGE IN FABRIC

CONTROL
POWER
HOME
LABORATORY

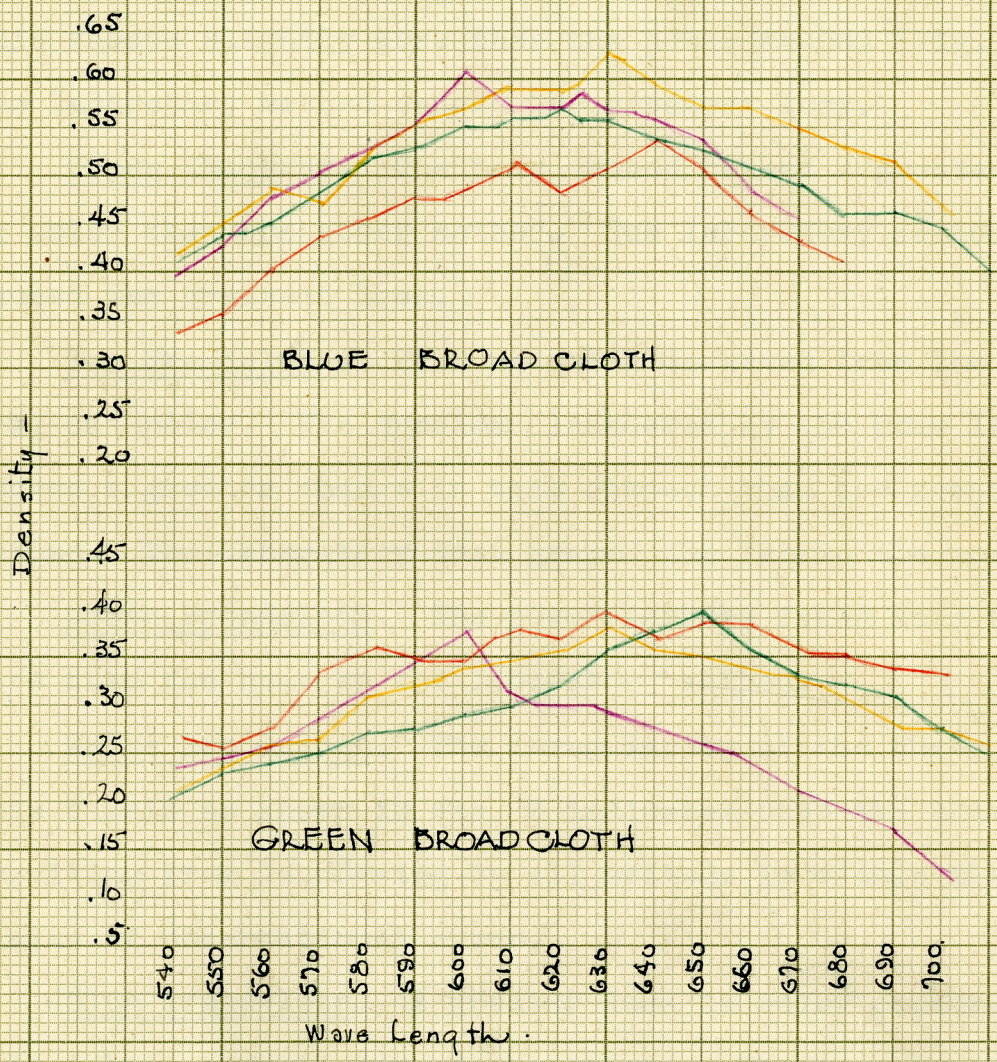


FIG. 3 — COLOR CHANGE IN FABRIC

the raising of the lines indicates a graying or darkening of the cloth (Fig. 3); the changing of the peak indicates a difference in hue.

Tan Chambray. The home method reduced the color of this fabric slightly more than the power method (Fig. 1). The laboratory method caused the greatest loss.

Green Chambray. The home method caused a greater loss of color than the power method. The laboratory method caused the greatest loss.

Tan Broadcloth. This material darkened from the original color. The specimen laundered by the home laundry showed a greater change in this respect than the power method. The laboratory test grayed the fabric the most.

Green Broadcloth. The power laundry faded this fabric more than the home or the laboratory method.

White Broadcloth. The irregularity of the curve for this fabric as shown in Fig. 2 indicates that the change resulting from laundering by all methods is within the limits of observational error.

Blue Broadcloth. A greater loss in color occurred in this fabric than in any of the others. The home laundry method caused a greater loss in color than the power method. The loss for the laboratory test was less than either of

Table X. Spectrophotometric Readings of Control and Twentieth Laundering of Tan Chambray

Wave length	Control Density	Power Density	Home Density	Laboratory Density
420			.30	.30
430			.33	.33
440			.35	.37
445		.36		
450	.23	.39	.36	.39
455	.25	.41		
460	.27	.47	.42	.43
465	.32	.47	.45	.47
470	.36	.47	.43	.44
475	.36	.46	.41	.41
480	.39	.46	.40	.37
485	.44	.41		
490	.39	.39	.39	.35
495	.38	.38		
500	.41	.34	.37	.34
510	.36	.31	.32	.29
520	.29	.29	.29	.25
530	.26	.31	.24	.23
540	.23	.28	.22	.22
550	.23	.22	.19	.20
560	.21	.20	.17	
570	.18	.20		
580	.18	.19		
590	.16	.17		
600	.17	.15		
610	.15	.13		

Table XI. Spectrophotometric Readings of Control and Twentieth Laundering of Green Chambray

Wave length	Control Density	Power Density	Home Density	Laboratory Density
520	.47	.46		
530	.51	.46		
540	.54	.47	.31	.39
550	.58	.50	.32	.43
560	.59	.53	.35	.45
570	.61	.55	.37	.46
580	.62	.56	.38	.48
585	.63	.57		
590	.64	.56	.39	.49
595	.63	.55		
600	.61	.56	.42	.57
605	.58	.56		
610	.57	.59	.42	.53
615	.55	.61		
620	.54	.59	.43	.53
625	.54	.57		
630	.53	.56	.44	.54
635				.55
640	.52	.55	.45	.54
645			.46	.53
650		.53	.47	.51
655			.45	
660			.44	.49
670			.42	.47
680			.41	.47
690			.40	.46
700			.39	.43
710			.35	.41
720			.32	.40

Table XII. Spectrophotometric Readings of Control and Twentieth Laundering of Tan Broadcloth

Wave length	Control Density	Power Density	Home Density	Laboratory Density
420				.31
430		.17	.36	.34
440	.35	.26	.39	.35
445		.31		.35
450	.36	.35	.39	.34
455		.40		
460	.37	.43	.40	.34
465	.38	.40		
470	.38	.34	.41	.30
475	.37		.43	
480	.37	.36	.44	.30
485	.35	.39	.41	
490	.33	.32	.37	.30
500	.32	.26	.35	.27
510	.31	.23	.34	.25
520	.27	.22	.33	.24
530	.24	.20	.30	.24
540	.24	.21	.29	.22
550	.22	.23	.28	.21
560	.20	.21	.26	.20
570	.19	.23	.24	

Table XIII. Spectrophotometric Readings of Control and Twentieth Laundering of Green Broadcloth

Wave length	Control Density	Power Density	Home Density	Laboratory Density
520		.19		
530		.21		
540	.27	.24	.22	.21
550	.26	.25	.24	.23
560	.28	.26	.26	.24
570	.34	.29	.27	.25
580	.36	.32	.31	.27
590	.35	.35	.32	.28
595		.35		
600	.35	.38	.34	.29
605	.37	.35		
610	.38	.31	.35	.30
615	.38	.30		
620	.36	.30	.36	.32
625	.39	.30	.37	
630	.40	.30	.38	.36
635			.37	
640	.36	.28	.36	.38
645				.39
650	.39	.26	.35	.40
655				.38
660	.39	.24	.34	.36
670	.36	.21	.33	.33
680	.35	.19	.31	.32
690	.34	.17	.28	.31
700	.34	.13	.27	.27
710			.26	.25
720			.24	

Table XIV. Spectrophotometric Readings of Control and Twentieth Laundering of White Broadcloth

Wave length	Control Density	Power Density	Home Density	Laboratory Density
540	.15	.15	.12	.13
550	.12	.15	.16	.14
560	.13	.16	.16	.17
570	.14	.15	.17	.18
580	.13	.15	.18	.17
590	.14	.16	.18	.18
600	.14	.15	.16	.19
610	.14	.15	.16	.20
620	.16	.15	.15	.21
630	.17	.19	.15	.21
635		.19		
640	.16	.19	.17	.20
645	.17	.20		
650	.22	.17	.20	.19
655	.19	.18	.21	.21
660	.16	.17	.20	.24
665			.17	.21
670	.16	.12	.16	.19
680	.14	.11	.15	.16
690	.13	.10	.14	.15
700	.12	.10	.13	.13

Table XV. Spectrophotometric Readings of Control and Twentieth Laundering of Blue Broadcloth

Wave length	Control Density	Power Density	Home Density	Laboratory Density
540	.34	.40	.41	.42
550	.36	.43	.44	.45
560	.41	.48	.45	.49
570	.44	.51	.48	.47
580	.46	.53	.52	.53
590	.48	.56	.53	.56
595	.48	.58		
600	.49	.61	.55	.57
605	.50	.59	.55	
610	.52	.57	.56	.59
615	.50	.58	.56	
620	.49	.58	.57	.59
625	.50	.59	.56	.61
630	.51	.57	.55	.63
635	.53	.57		.61
640	.54	.56	.54	.59
650	.51	.54	.53	.57
660	.46	.46	.51	.57
670	.43	.45	.49	.55
680	.41		.46	.53
690			.46	.51
700			.44	.47
710			.40	.46
720				.44

the others.

The visual comparison of all the laundered specimens was made. In this test eight persons endeavored to arrange the fabrics for each group in order of the degree of change in color. No individual was able to place all the specimens in their correct order (Table XVI). One person arranged correctly all six of the twelve sets, another arranged correctly two sets, all other sets were incorrect in arrangement. Twenty launderings affected an apparent change in all groups. Forty-three of the total ninety-six sets arranged were correct in placement of the control and the first laundering specimen, and forty-six of the twentieth specimen.

The measurements of the six by six inch marked areas of the different laundered specimens varied between laundering of the same group (Table XVIII). In some instances the twentieth laundered specimen showed an increase in size over the other laundered ones of the same fabric. In some instances the material showed an increase in length over the control. The ironing of the fabrics evidently caused a stretching in some instances. This irregularity in length and width of the laundered specimens influenced the tensile strength of the strips made from them. A shortening of the

Table XVI. Laundered and Unlaundered Specimens as Arranged from Dark to Light in Order of Apparent Change in Color

Observer	Tan Chambray		Green Chambray		Tan Broadcloth		Green Broadcloth		White Broadcloth		Blue Broadcloth	
	Power	Home	Power	Home	Power	Home	Power	Home	Power	Home	Power	Home
No. 1	C	C	C	C	C	C	C	C	C	C	C	C
	1	1	1	2	1	1	15	4	1	2	15	4
	3	2	2	1	2	5	20	3	4	20	2	10
	4	3	3	3	3	4	4	1	3	15	1	15
	15	5	5	5	5	3	10	5	2	4	5	5
	20	4	10	4	10	2	5	10	5	5	10	3
	2	15	4	10	4	20	3	15	10	10	4	1
	5	10	15	15	15	10	1	2	15	3	3	2
	10	20	20	20	20	15	2	20	20	1	20	20
No. 2	5	15	C	C	5	2	15	15	3	C	C	C
	2	10	2	2	10	3	20	5	C	10	15	20
	10	20	1	5	3	15	1	10	5	1	1	10
	20	4	5	3	15	10	C	C	2	3	2	15
	C	2	3	1	C	20	10	20	4	4	10	4
	3	1	4	4	20	4	2	2	15	5	5	1
	1	C	10	10	2	5	4	4	1	20	4	5
	15	5	20	15	4	C	3	1	20	2	3	3
	4	3	15	20	1	1	5	3	10	15	20	2
No. 3	C	C	C	C	15	C	C	C	C	C	C	C
	1	1	1	1	4	1	5	1	20	2	15	4
	3	2	2	2	20	3	2	5	1	20	10	10
	2	3	3	5	3	2	3	10	4	1	5	5
	10	4	5	3	1	5	4	4	2	3	1	15
	5	10	4	4	10	4	10	3	3	5	4	3
	20	5	15	10	5	10	1	2	15	4	20	2
	4	20	10	15	C	15	15	15	10	10	2	20
	15	15	20	20	2	20	20	20	5	15	3	1
No. 4	C	C	C	C	C	C	C	3	20	C	C	C
	2	10	1	2	1	20	20	1	10	20	5	20
	4	20	2	1	2	15	10	5	2	15	15	4
	3	3	5	3	4	10	3	10	15	2	4	1
	1	2	10	5	3	2	5	C	5	4	1	5
	5	15	3	4	5	3	15	20	1	10	2	3
	15	4	4	10	15	1	2	2	C	1	10	10
	10	1	20	15	10	5	1	15	4	5	20	15
	20	5	15	20	20	4	4	4	3	2	3	2
No. 5	C	C	C	C	10	C	20	C	C	C	C	C
	3	1	3	1	20	1	15	20	5	2	3	1
	1	4	2	15	3	4	4	2	3	20	20	10
	2	2	1	5	15	2	1	3	1	1	1	4
	4	3	10	10	5	3	3	4	4	3	4	5
	5	5	4	4	4	5	10	10	20	5	2	3
	15	10	5	3	2	15	5	5	15	4	15	15
	10	15	15	2	C	10	C	15	10	10	5	20
	20	20	20	20	1	20	2	1	2	15	10	2
No. 6	C	C	C	C	C	C	C	C	C	C	C	C
	1	3	1	1	1	1	2	2	1	2	5	5
	2	5	2	2	10	4	5	3	20	20	15	10
	4	2	3	3	20	2	10	1	15	1	10	4
	15	1	5	5	15	5	3	10	5	3	2	20
	20	4	10	4	5	10	4	5	10	5	1	2
	3	10	4	10	2	3	15	4	2	4	4	15
	10	15	20	15	4	20	20	15	4	10	3	1
	5	20	15	20	3	15	1	20	3	15	20	3
No. 7	C	C	C	C	C	C	20	C	C	C	C	C
	1	1	1	1	1	1	15	1	1	1	1	15
	2	2	2	2	2	2	C	2	2	20	2	5
	3	3	3	3	3	3	5	3	3	2	3	10
	4	4	4	4	4	4	10	5	5	15	15	1
	5	5	5	5	5	5	3	10	4	4	5	4
	10	10	10	10	10	10	2	4	10	5	10	2
	15	20	15	15	15	15	1	15	20	3	4	3
	20	15	20	20	20	20	4	20	15	10	20	20
No. 8	3	C	C	C	C	C	C	C	C	C	C	C
	1	1	1	1	1	1	1	1	1	1	2	2
	15	3	2	2	2	2	2	2	2	2	20	3
	C	2	3	3	3	3	3	3	3	3	3	4
	2	4	4	4	4	4	4	5	15	4	5	10
	5	5	5	5	5	5	5	4	5	10	10	5
	10	10	10	10	15	15	10	10	4	5	1	15
	20	15	20	15	10	20	15	15	10	15	4	1
	4	20	15	20	20	10	20	20	20	20	15	20

C indicates unlaundered specimen. Numeral indicates number of times the specimen was laundered.

Table XVII. Shrinkage in Inches Per Yard of Twentieth Laundering Specimens

Method	Tan Chambray		Green Chambray		Tan Broadcloth		Green Broadcloth		White Broadcloth		Blue Broadcloth	
	W	F	W	F	W	F	W	F	W	F	W	F
Power	3.00	0.00	3.00	1.50	1.50	0.75	1.50	0.00	3.37	0.75	2.25	0.00
Home	1.30	0.75	1.12	1.00	0.75	0.75	2.25	0.19	1.50	0.19	2.50	+0.19*
Laboratory	1.12	0.75	1.50	1.00	0.75	+0.75*	0.75	0.75	0.75	0.37	1.50	0.00

*Indicates a stretching of fabric.

Table XVIII. Shrinkage in Inches Per Yard of All Laundering Tests

Launderings	Tan Chambray W	Tan Chambray F	Green Chambray W	Green Chambray F	Tan Broadcloth W	Tan Broadcloth F	Green Broadcloth W	Green Broadcloth F	White Broadcloth W	White Broadcloth F	Blue Broadcloth W	Blue Broadcloth F
Power Laundry												
1	1.95	0.00	1.50	0.94	0.19	0.19	1.12	0.00	1.50	0.00	1.50	0.00
2	2.01	0.00	1.62	1.50	0.68	0.37	1.18	0.00	1.56	0.00	1.93	0.00
3	3.00	0.75*	3.00	0.00	0.75	0.00	1.87	0.37*	2.25	0.00	2.38	0.75*
4	2.50	0.37	3.00	0.00	0.75	0.37	1.50	0.37*	1.75	0.91	2.25	0.68*
5	3.37	0.75*	3.37	0.00	0.75	0.75*	2.25	0.75*	3.00	0.75	2.25	0.75*
10	3.75	1.50*	3.75	0.75	1.50	0.75*	2.25	1.12*	3.00	0.75	3.00	1.12*
15	2.25	0.00	3.03	0.75	1.12	0.75*	1.50	0.00	0.91	0.75	2.25	1.50*
20	3.00	0.00	3.00	1.50	1.50	0.75*	1.50	0.00	3.37	0.75	2.25	0.00
Home Laundry												
1	1.50	0.75	2.25	1.12	1.50	1.12	1.56	0.00	1.50	0.62	3.50	0.00
2	1.25	0.94	2.25	1.50	0.37	1.00	1.50	0.00	1.24	0.37	3.50	0.00
3	1.50	0.00	2.55	0.37	1.50	0.75	1.75	0.19	2.25	1.12	3.75	0.75*
4	1.63	0.37	1.74	0.75	0.37	1.12	1.50	0.00	1.50	0.00	2.00	0.00
5	1.75	0.00	2.86	0.75	1.74	0.62	2.25	0.37	2.38	0.75	2.25	0.00
10	0.50	0.75	3.00	0.37	1.50	0.37	2.86	0.00	3.00	0.75	2.50	0.75*
15	2.50	0.75	2.25	1.50	0.75	1.12	1.50	0.37	1.50	0.37	2.25	0.37*
20	1.30	0.75	1.12	1.00	0.75	0.75	2.25	0.19	1.50	0.18	2.50	0.19*
Laboratory												
1	1.50	0.00	1.87	0.75	1.12	0.75	1.50	0.00	2.25	0.75	1.50	0.00
2	2.38	0.37	1.12	1.00	1.50	0.37	1.50	1.37	1.12	0.75	3.75	1.50
3	1.25	0.00	2.00	0.75	1.12	0.56	1.12	0.00	1.12	0.00	2.38	0.00
4	2.25	1.50	2.00	1.50	0.75	0.87	2.00	0.00	1.50	0.75	1.75	0.00
5	1.50	0.75	1.50	0.75	0.75	1.00	1.30	0.75	1.98	0.75	1.17	0.00
10	2.00	0.00	1.50	0.75	0.37	0.75	1.50	0.75	0.75	0.75	1.50	0.00
15	1.75	0.75	1.00	1.25	0.75	1.12	2.25	0.00	1.50	0.75	3.75	0.00
20	1.12	0.75	1.50	1.00	0.75	0.75	0.75	0.75	0.75	0.37	1.50	0.00

*Indicates a stretching of fabric.

strip would increase the twist per inch in the yarn, and this would influence the tensile strength of the strip.

Comparison of the effect of the laundry methods in terms of shrinkage could not be made under the conditions of this study.

SUMMARY OF RESULTS

A summary of the results obtained under the conditions of this study indicate:

1. The method of sampling was sufficiently accurate for this study.
2. In three-fourths of the cases, counting both warp and filling, the loss in tensile strength was greater in the portions laundered by the home management houses.
3. In ten laundered specimens the loss in tensile strength was more than ten per cent for the twentieth laundering. Six of these were laundered by the home method and four by the power method.
4. All fabrics showed some change in color for all laundering methods. The white broadcloth, tan and green chambrays became slightly grayer and darker. The darker colored fabrics varied in the

type and extent of color change. The home method caused a greater change in color than the power methods.

6. Shrinkage was usually greater in the warp than in the filling for all methods but results were not sufficiently uniform to permit any comparison of the effect of the different laundry methods in terms of shrinkage.

CONCLUSIONS

1. Data obtained under the conditions of this study indicate that power methods were no more severe on the strength of these fabrics than home methods.
2. Spectrophotometric analyses show that power methods had slightly less effect on the loss of color in these fabrics.
3. No conclusions could be drawn in regard to a comparison of the two methods of laundering on the shrinkage of these fabrics.
4. The tensile strength strips should be based upon thread count and not upon width.
5. Some arrangement should be made whereby the

fabrics could be dried under definite tension or without tension in order to obtain accurate shrinkage measurements.

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