A COMPARISON OF SHRINKAGE DUE TO LAUNDERING OF COTTON, LINEN AND RAYON FABRICS PRESSED UNDER CONTROLLED TENSIONS

by

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INTRODUCTION

Shrinkage of textile fabrics due to laundering is a basic consideration in both the use and production of these materials. Studies of cotton sheeting have shown that shrinkage in the warp was as great as 9.5 per cent, or over 10 inches in the length of a sheet. This decrease is sufficient to make the sheet unsatisfactory for use after laundering. In a group of chambray and covert fabrics the amount of warp shrinkage ranged from nine to 14 per cent and the filling shrinkage varied from three to six per cent. In an analysis of 84 cotton dress prints, warp shrinkage ranged from 2.6 to 6.8 per cent. Garments made of fabrics with shrinkage as great as these would be totally unfit to meet demands made of them. Cotton fabrics, however, can be successfully shrunken by mechanical means. Linen fabrics react in a manner similar to that of cotton fabrics.

Since rayon has become such a widely used fiber, attention has been focused on shrinkage of rayon fabrics. Many fabrics of rayon will shrink excessively and some will stretch. Some spun rayon dress fabrics have been found to shrink as much as 9.9 per cent and others to stretch 3.6 per cent. Because of the variability in the kind of rayon fiber used, the yarn structure and fabric construction, the shrinkage of rayons is highly unpredictable.

The methods for determining the amount of shrinkage have been criticised unfavorably. Specifications for shrinkage measurements either require hand ironing or pressing with the flat-bed press. Shrinkage after pressing with the hand iron varies greatly with technicians in different laboratories. Almost any tension can be applied in hand ironing, and thus the shrinkage data on the same fabric may be different for each determination.

Since shrinkage determinations have not been consistent in the past, this study was made to compare the effects of various tensions on the shrinkage of cotton, linen and rayon fabrics.

REVIEW OF LITERATURE

No studies were found which reported comparisons of shrinkage due to laundering of cotton, linen and rayon fabrics. Neither have studies been reported on these fabrics pressed under controlled tensions.

The literature reviewed might be classified as that related (a) to causes of shrinkage, (b) to the shrinkage of various kinds of fabrics, such as cotton, linen and rayon, and (c) to means of controlling shrinkage.

Shrinkage in woven fabrics has been attributed to the use of excessive tensions in manufacturing and finishing, to yarn shrinkage and to fiber shrinkage.

Harwood (7) stated that throughout the entire weaving and finishing processes yarns are under tensions. He believed the amount of this tension and the degree to which this tension becomes "set" in the finishing process is largely responsible for fabric shrinkage.

According to Mauersberger (12) fabrics of plain weave evidence the greatest shrinkage, for the greatest interlacing takes place in this weave. The more a yarn is bent out of shape in the process of weaving, the greater the tension, and the greater the adjustment in washing that may be expected. He stated that if a fabric is densely filled or picked, shrinkage is almost impossible for there is no space for swelling during washing. An open, loosely woven fabric can be more easily tensioned, which results again in greater shrinkage. In discussing shrinkage of spun rayon fabrics, Mauersberger said that shrinkage of spun rayon fabric, or its components, would occur in direct proportion to the tension given it in spinning, weaving and finishing.

Harwood (7) divided shrinkage into three phases: fiber shrinkage, yarn shrinkage and shrinkage due to increase of crimp. He believed that when considering the shrinkage of a fabric on laundering, fiber shrinkage can be quite legitimately neglected. This author claimed that cotton fibers swell when wetted with the result that yarns increase in diameter and cannot span as great a length as formerly, consequently the yarns contract. Since the yarns have a larger diameter, they require more room and can only accomodate themselves in the fabric by a greater amount of crimp. They become more wavy and are able to cover less distance in the cloth; therefore the cloth contracts or shrinks.

Yarn and fiber shrinkage are intimately bound up with one another. According to Collins (3) the structure of yarns enters all aspects of the problem of shrinkage. Twist, size, compactness, and degree of flattening are important features of yarn construction which influence shrinkage. This author stated that as twist is increased, yarn shrinkage has been shown to increase.

Collins (3) also said that fibers in high humidity or in water swell, thereby increasing in diameter, but the change in length is negligible. Greater swelling and shrinkage effects are possible with cellulose rayon fibers than with cotton fibers. This author claimed that rayon yarns can show serious shrinkage as a result of marked fiber shrinkage.

Clayton (2) found that cotton fabrics are more stable than other fabrics; in a discussion accompanying Marks' (11) symposium, Clayton also stated that a stable fabric is a fabric which, when subjected to actual use in a garment, will shrink approximately the same amount each time it is laundered, i.e., "at the first wash you get a shrinkage of half a per cent, on the second wash a shrinkage of 0.6 per cent, the third wash 0.7 per cent and the fourth wash 0.5 per cent." In each instance the percentage shrinkage is based upon the original dimensions of the fabric pressed with the flat-bed press. The change, due to laundering, in the dimensions of an unstable fabric is greater in most cases than for a stable fabric and may be negative as well as positive. "If you find on the first wash that that fabric shrinks one-half a per cent, the next wash 1.0 per cent, and the third wash 2.5 per cent, you know that such a fabric is not stable. Whatever the condition is that has prevented its shrinkage its full amount the first time is being changed by washing" (2). Stable fabrics can be fully shrunk by mechanical means; unstable fabrics cannot be fully shrunk by this method.

Clayton continued by stating that some rayon fabrics may be classed as stable fabrics. There are also a number of treatments, such as resin finishes and others, which will stabilize rayon fabrics. Some of these, however, may be removed by several launderings.

Chaky (1) stated that there had been recent complaints pertaining to shrinkage in various "spun rayon and also flat rayon fabrics." Shrinkage could be remedied in these fabrics by (a) preshrinking before or during finishing operations, (b) cutting down mill tensions during manufacturing of the cloth, (c) proper handling of the cloth in the wet processes of scouring and dyeing and (d) the incorporation of proper chemicals in finishing.

Various mechanical treatments have done much to fix the shrinkage of cotton (13). New processes have been developed, whereby rayon fabrics can be controlled as far as shrinkage and stretch are concerned. This stabilization process is attained chemically and mechanically. It is claimed that these finishes will not be destroyed by laundering.

METHODS OF PROCEDURE

Materials

Twenty-five fabrics were selected for study. These were classified in five groups: cotton, linen, continuous filament viscose rayon, continuous filament acetate rayon and spun viscose rayon. The materials chosen were those commonly used for dresses, blouses, slips, and children's clothing.

Five fabrics were chosen within each of the five groups. The fabrics in each group were selected for similarity in weight, handle and appearance. Color was of no concern in this study. None of the fabrics had had a physical or chemical treatment which might affect shrinkage, so far as could be determined.

The fabrics ranged in price from $.29 to $1.85 and were selected from retail establishments in Manhattan, Kansas; Topeka, Kansas; Kansas City, Missouri; and Wichita, Kansas. The cottons ranged in price from $.29 to $.79, the linens from $.98 to $1.85, the continuous filament viscose rayon from $.59 to $.95, the continuous filament acetate rayon from $.59 to $1.00 and the spun viscose from $.79 to $1.49. Places of purchase and costs are given in Table 1. In width they ranged from 35 inches to 44 inches. Mounted samples of these fabrics are shown in Plates I, II, III, IV, and V.

EXPLANATION OF PLATE I

Cotton fabrics used in this study.

A Batiste

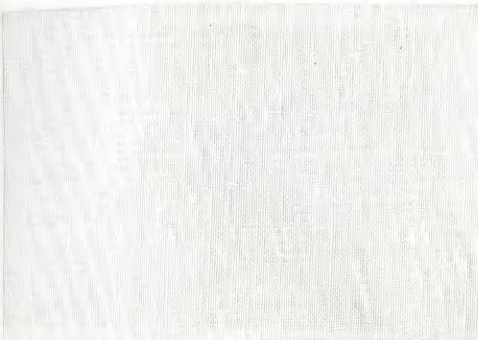
B Cambric

C Chambray

D Percale

E Print

PLATE I



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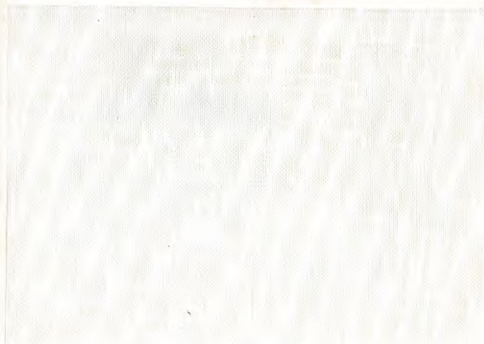

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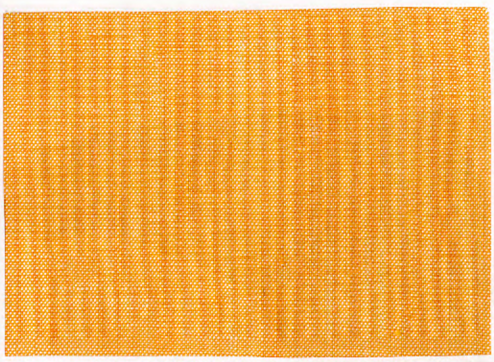

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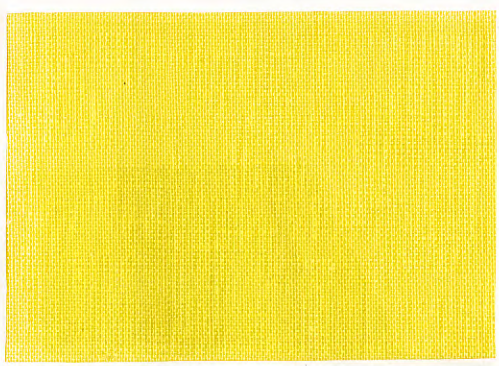


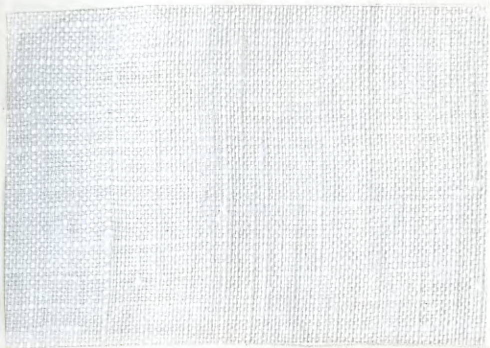
E

EXPLANATION OF PLATE II

Linen fabrics used in this study.

F	Dress linen
G	" "
H	" "
I	" "
J	Unbleached linen

PLATE II



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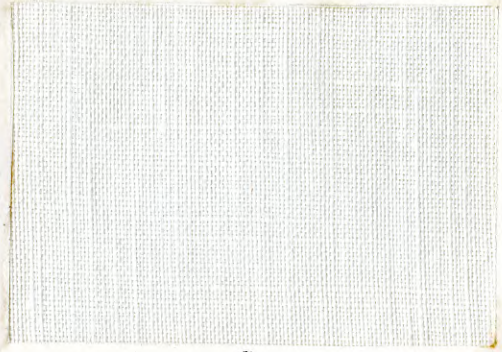

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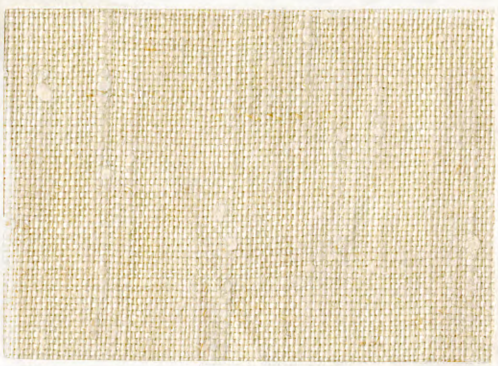

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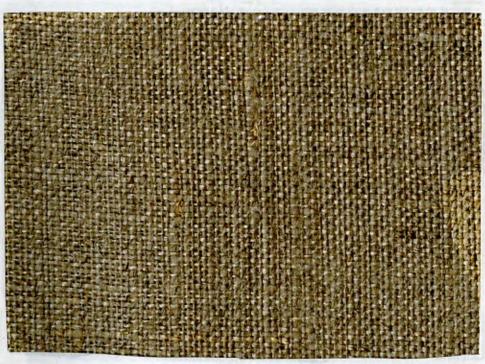
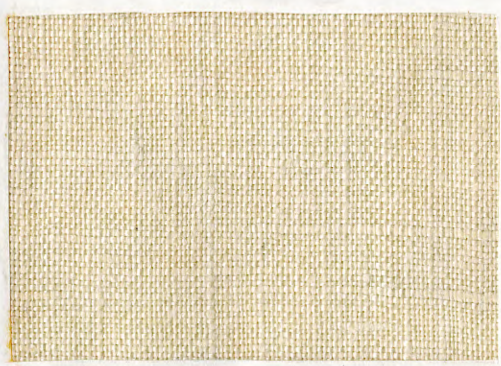


I



J

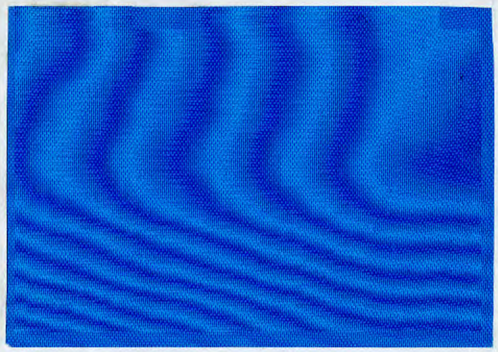
EXPLANATION OF PLATE III

Continuous filament viscose rayon fabrics used in this study.

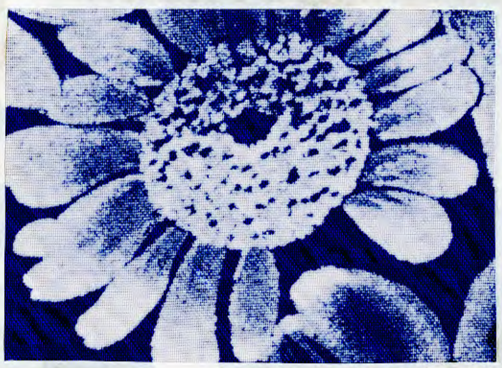
K	Flat crepe
L	" "
M	" "
N	" "
O	" "

PLATE III

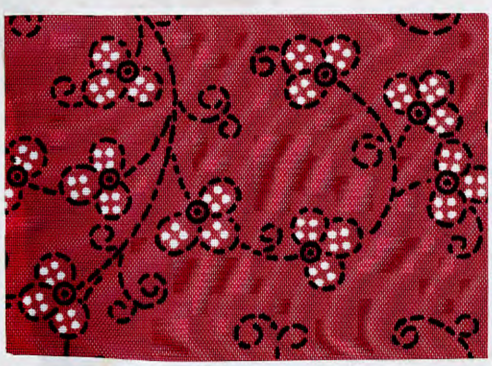
K



L



M



N

O

EXPLANATION OF PLATE IV

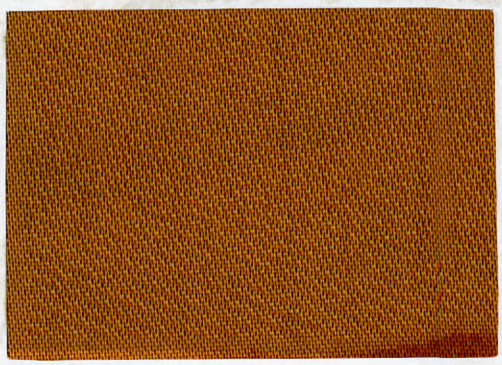
Continuous filament acetate rayon fabrics used in this study.

P	Flat crepe
Q	" "
R	Sharkskin
S	Flat crepe
T	Sharkskin

PLATE IV

P

Q



R

S

T

EXPLANATION OF PLATE V

Spun viscose rayon fabrics used in this study.

U	Shantung
V	"
W	"
X	Dress fabric
Y	" "

Physical Tests

Identification of fibers was made by microscopic examination. All fabrics were of plain weave. The thread count, thickness, weight per square yard, crimp, yarn counts, twist, finish, breaking strength and elongation were determined for each fabric. Thread count, thickness, weight per square yard, finish, breaking strength and elongation were determined by methods approved by Committee D-13 (4). To determine crimp, Schwarz's microscopic method, employing the camera lucida, was used (16).

Yarn counts were determined by the following method. Fifty yards of warp yarn and 50 yards of filling yarn from each fabric were dried to constant weight. The total length was calculated by adding the percentage crimp. The yarn counts were calculated, using the Typp system, from these weights and total lengths.

The direction of twist was determined by observation and the amount of twist with the Suter twist counter. A ten inch length was inserted in the counter and untwisted. Ten determinations were made and the standard error calculated.

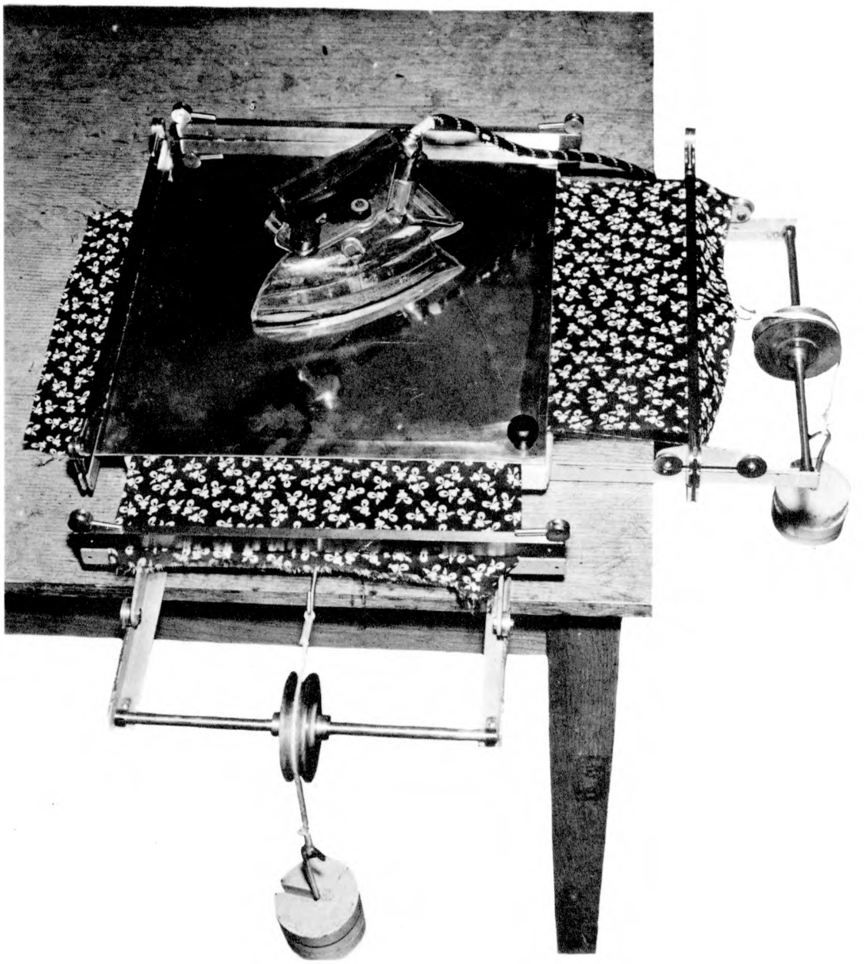
Preparation of Materials for Shrinkage Tests

Samples for testing were prepared according to directions given for the tension presser[1] (10, 18). A square 25 inches by 25 inches was cut on the exact warp and filling threads. One selvage was retained to make warp and filling differentiation easier.

[1]The tension presser was developed by the U.S. Testing Co., Inc.

EXPLANATION OF PLATE VI

The tension presser was developed by United States Testing Co., Inc. to test shrinkage and dimensional restorability of fabrics. Specimens, with certain marked area for measurement of shrinkage, are clamped into the apparatus by means of four tabs or extensions. The specimens are pressed with an aluminum plate heated by an electric iron. Certain tensions may be applied by attaching weights to the movable clamp bars.



These squares were then marked with the template provided with the tension presser. This is a galvanized sheet of iron 19.5 inches by 19.5 inches. It was placed 2.75 inches from each edge of the 25 inch square of fabric and adjusted so the lines of the ten-inch square followed the warp and filling threads. With indelible ink, the template was outlined and the ten-inch square in the center was marked. Care was taken that the ten-inch square was no closer to the selvage than one-tenth the width of the material. To provide tabs for fastening the specimens in the tension presser, a one and 0.25 inch square was removed from one corner and a 4.75 inch square from the corner diagonally opposite. From the other two corners, rectangles 1.25 by 4.75 inches were cut, leaving two short tabs and two long tabs.

Each side of the ten-inch square was then permanently marked with a thread of contrasting color by using a running stitch. Knots were tied one and one-half inches from both ends of the stitching so that it would not interfere with negative shrinkage. Lines at the edges of the template were marked and stitched on the tabs to be used as guide lines for clamping the specimen in the machine.

The edges of the tabs were then turned under once and machine-stitched to prevent raveling and each fabric was given a letter and a number for identification.

Laundering and Pressing Procedure

Laundering was done in an electric cylinder-type washing machine with reverse wash wheel. It was approximately 13 by nine inches with a capacity of 18 liters of water.

Distilled water was used for both washing and rinsing procedures. Ninety grams of soap flakes were dissolved in the 18 liters of water making a 0.5 per cent neutral soap solution. Water for launderings was heated to 71° C., and this temperature maintained by keeping the machine on an electric hot plate.

The load of the machine was 13 samples with a dry weight of approximately one pound. A blank was used in the second load to balance the loads.

The machine was operated for 30 minutes as recommended by United States Testing Co., Inc. in the instructions for use of the tension presser (17).

The fabrics were then removed and rinsed three times, by gently squeezing and pressing, in beakers of distilled water at a temperature of 38 to 39° C. The water was gently squeezed from them so the fabric was not distorted in any way. They were then rolled in towels and allowed to stand five to 10 minutes before pressing.

Each specimen was then laid on the bed of the presser and all noticeable wrinkles smoothed out. The aluminum template of the presser was placed over the ten-inch square. This template had been heated by a five pound iron with controlled heat. The iron maintained at a temperature of 155^{o}-160^{o}, was preheated five minutes, then placed on the aluminum template for five minutes before the template was placed on the specimen. The template was lifted every 30 seconds to release trapped steam. After the steam ceased to rise the template was allowed to remain in place until the fabric was completely dry. The tabs were then ironed dry with a hand iron, taking care to cause no strain on the cloth.

The specimen was allowed to stand 1.5 hours at standard conditions and then measured at three points in each direction to determine the dimensional change without application of any tension. All measurements were recorded in percentage of warp and filling change to the nearest one-half per cent.

The specimens were then immersed in distilled water at 38^{o} to 39^{o} C., allowed to stand for a few minutes, then squeezed gently, wrapped in a towel, and permitted to stand five to 10 minutes before pressing under tension.

The tension presser has two movable clamp bars and two stationary clamp bars which hold the specimen in place. The two short tabs were fastened in the two stationary clamp bars and the long tabs in the movable ones. The jaws were placed along the guide lines and fastened with the clamps in such a manner that the weights applied did not distort the ten-inch square. The one-half pound weights were then applied on the movable clamps and the weights released at the same time. The sample was then pressed as before until dry.

The tensions were released and the samples removed from the presser. The wet tabs were ironed dry, the specimen conditioned

1.5 hours and measured again in the same manner as it was when no tension was used.

This process of wetting, letting stand in a towel, pressing, conditioning and measuring was repeated for one, three, and four pounds of tension.

The fabrics were laundered five successive times. Pressing after each laundering was done without tension and at one-half, one, three and four pounds tension and measurement of shrinkage was made for each laundering and tension in both warp and filling. The percentage of shrinkage for the five groups of fabrics after one to five launderings pressed under various tensions is given in Table 2.

Determination of Dimensional Restorability

Fabrics may be stretched by applying tension in pressing. With the tension presser certain weights can be applied and the tension required to stretch specimens back to their original dimensions can be determined. A fabric, to be considered satisfactory from a restorability standpoint, must not show more than ±2.0 per cent dimensional change in warp and filling measurements, when compared with original dimensions. A fabric is not dimensionally restorable when it shows a gain, in excess of two per cent, with the lightest tension, i.e., one-half pound, applied; or when it shows loss, in excess of two per cent, with four pounds of tension. Slight tension is applied in hand ironing when merely smoothing out wrinkles and moving the iron. "Tensions in excess of four pounds are impractical to apply in hand ironing" (17).

FINDINGS AND DISCUSSION

Physical Characteristics of Fabrics

The physical characteristics of cotton, linen, continuous filament viscose rayon, continuous filament acetate rayon and spun viscose rayon are given in Table 1.

The yarns of staple fibers, i.e., cotton, linen, and spun viscose rayon, had a moderate amount of twist; those of continuous filament had very slight twist. The continuous filament viscose rayon had S-twist in the warp and filling, the cotton, linen and spun viscose rayon had Z-twist in the warp and filling and the continuous filament acetate rayon combined S-twist and Z-twist in all but one fabric; it was Z-twist in both warp and filling.

Statistical Analysis of Shrinkage Due to Laundering

The analysis of variance was used to evaluate the data on shrinkage. In interpreting differences by this analysis a probability of five per cent or less indicated significant difference.

Table 2 shows the data on shrinkage of the 25 fabrics. Shrinkage in percentage was measured in warp and filling after one, two, three, four and five launderings pressed with no tension and one-half, one, three and four pounds. Table 3 gives the means of the percentage shrinkage for fabrics after launderings under various tension, both warp and fillingwise. The results of the statistical analysis are shown in Table 4.

Table 1. Physical characteristics, place of purchase and cost of cotton, linen, continuous filament viscose, continuous filament cellulose acetate and spun viscose rayon.

Fabrics	Thread count Warp	Thread count Filling	Thickness (in.)	Wt. per sq. yd. (oz. dry wt.)	Crimp per cent Warp	Crimp per cent Filling	Yarn counts (Typp dry wt.) Warp	Yarn counts (Typp dry wt.) Filling	Direction of twist, turns per inch and standard error Warp	Direction of twist, turns per inch and standard error Filling	Finish (per cent)
Cotton											
1 Batiste	102.4	91.4	.0079	2.6	5.4	12.9	50.2	45.8	Z32.0±1.4	Z38.4±1.3	1.0
2 Cambric	86.4	75.1	.0085	3.0	5.3	9.5	32.6	29.8	Z26.7±1.2	Z20.9±0.9	2.8
3 Chambray	86.0	68.4	.0097	2.6	6.6	13.0	37.8	38.7	Z28.5±1.5	Z19.7±0.6	2.2
4 Percale	66.2	57.6	.0071	2.4	2.3	4.2	29.2	35.2	Z25.9±0.0	Z24.6±1.1	3.8
5 Print	105.8	93.4	.0093	3.2	6.6	14.3	38.6	41.2	Z25.9±0.9	Z25.1±0.8	2.2
Linen											
1 Dress linen	48.0	41.4	.0095	3.7	4.3	5.4	16.6	17.0	Z7.5±0.7	Z7.9±0.7	1.2
2 " "	48.0	46.8	.0083	3.6	4.9	3.6	17.9	13.9	Z10.3±0.5	Z9.2±1.0	1.4
3 " "	37.4	32.8	.0131	5.6	3.8	5.6	7.8	7.3	Z9.2±0.8	Z9.9±0.7	3.8
4 " "	37.0	31.0	.0149	5.0	5.1	5.2	8.2	8.4	Z7.3±0.4	Z7.6±0.6	1.4
5 Unbleached	31.8	37.4	.0134	3.0	3.5	3.3	8.2	6.4	Z9.1±0.8	Z9.1±0.6	5.6
Viscose (Continuous filament)											
1 Flat crepe	93.4	69.6	.0056	2.4	4.0	6.3	48.8	32.5	S3.36±.08	S3.18±.08	2.6
2 " "	93.4	66.2	.0069	2.3	5.3	4.8	47.6	32.0	S3.05±.06	S2.78±.06	2.0
3 " "	94.4	71.6	.0065	2.4	4.7	5.7	48.2	32.5	S3.59±.07	S2.38±.06	1.7
4 " "	97.0	76.2	.0065	2.5	6.2	5.8	47.5	50.0	S3.64±.06	S3.25±.06	2.4
5 " "	95.0	70.9	.0058	2.4	4.9	7.4	52.1	31.7	S3.86±.06	S2.69±.04	0.4
Acetate (Continuous filament)											
1 Flat crepe	93.2	69.2	.0062	2.3	4.1	6.7	50.7	33.4	S1.64±.06	Z2.36±.18	0.1
2 " "	92.8	68.8	.0070	2.4	6.5	8.4	65.3	33.8	S1.90±.14	Z2.46±.22	0.1
3 Sharkskin	60.2	46.2	.0080	3.2	1.7	6.9	34.2	24.2	Z1.30±.18	S2.44±.22	1.3
4 Flat crepe	92.8	70.0	.0059	2.1	9.5	8.8	51.9	24.3	Z2.52±.16	Z3.02±.20	0.4
5 Sharkskin	63.6	47.0	.0078	3.1	9.8	9.2	22.4	24.4	Z2.92±.36	S2.46±.18	1.8
Viscose (Spun)											
1 Shantung	44.4	43.0	.0191	4.0	8.9	9.0	14.0	12.2	Z15.2±2.0	Z17.8±1.0	3.5
2 "	68.3	38.9	.0143	3.3	9.1	9.1	30.8	12.8	Z14.9±1.3	Z15.6±1.3	1.8
3 "	45.3	42.1	.0190	4.0	9.1	8.6	13.7	12.3	Z18.0±2.5	Z20.3±7.3	3.3
4 Dress fabric	44.1	44.2	.0196	4.6	9.1	9.1	12.8	11.7	Z20.9±4.5	Z19.1±4.7	3.6
5 " "	52.9	45.9	.0156	4.4	8.9	8.4	14.2	13.3	Z15.2±4.7	Z18.8±5.1	0.6

Fabrics	Breaking strength and standard error (pounds) Dry Warp	Dry Filling	Wet Warp	Wet Filling	Elongation and standard error (per cent) Dry Warp	Dry Filling	Wet Warp	Wet Filling	Width (in.)	Cost per yd.	Place purchased
Cotton											
1 Batiste	34.1±1.1	32.6±0.3	40.6±0.4	37.3±1.1	.19±.00	.33±.01	.29±.00	.41±.01	35	$0.79	Cole's, Manhattan, Kansas
2 Cambric	40.5±0.3	26.4±0.9	43.7±1.3	28.8±1.0	.21±.00	.33±.01	.36±.00	.41±.01	36	0.49	" " "
3 Chambray	37.8±0.3	28.0±0.7	41.8±0.7	30.8±0.6	.24±.00	.31±.00	.32±.00	.37±.01	35	0.69	" " "
4 Percale	43.2±0.3	22.8±0.7	40.5±0.5	21.5±1.2	.21±.00	.38±.00	.30±.00	.35±.01	36½	0.29	Ward Keller, Manhattan, Kansas
5 Print	46.8±0.4	45.1±1.6	54.6±1.7	46.5±2.2	.29±.00	.48±.01	.36±.00	.49±.01	35	0.69	" " " "
Linen											
1 Dress linen	58.8±1.4	46.3±0.4	65.6±2.0	48.9±1.4	.17±.00	.20±.00	.18±.00	.20±.00	36	0.98	Ward Keller, Manhattan, Kansas
2 " "	28.4±1.7	41.0±0.4	41.0±2.4	50.8±2.5	.15±.01	.23±.01	.16±.00	.20±.01	36	1.50	Crosby Bros., Topeka, "
3 " "	57.8±2.4	45.4±1.4	60.8±1.6	48.6±2.0	.19±.00	.25±.00	.24±.00	.24±.01	44	1.85	" " " "
4 " "	40.1±2.0	20.9±0.8	46.9±1.3	24.4±2.6	.17±.00	.17±.01	.17±.00	.14±.01	36	1.50	" " " "
5 Unbleached	73.5±0.4	75.3±2.5	110.9±4.4	95.0±3.3	.19±.01	.25±.01	.34±.01	.30±.01	36	1.25	" " " "
Viscose (Continuous filament)											
1 Flat crepe	39.6±0.2	41.0±0.2	16.2±0.4	15.9±0.2	.62±.01	.61±.00	.76±.02	.65±.02	39	0.59	Cole's, Manhattan, Kansas
2 " "	21.6±0.7	20.4±0.4	5.7±0.2	4.8±0.0	.34±.01	.30±.01	.22±.01	.29±.01	42	0.89	Ward Keller, Manhattan, Kansas
3 " "	33.6±0.6	35.9±0.3	13.2±0.6	11.3±0.2	.49±.01	.52±.01	.44±.02	.40±.01	39	0.59	J. C. Penney Co., " "
4 " "	38.7±1.0	42.7±0.3	12.7±0.3	14.2±0.3	.58±.00	.58±.01	.48±.01	.42±.01	38	0.59	Montgomery Ward Co." "
5 " "	36.3±0.3	36.4±0.4	15.0±0.3	13.1±0.8	.48±.00	.52±.01	.46±.01	.47±.01	39	0.95	Cole's, Manhattan, Kansas
Acetate (Continuous filament)											
1 Flat crepe	17.8±0.8	17.1±0.4	12.5±0.3	12.2±0.2	.45±.02	.36±.01	.75±.03	.72±.03	41	0.69	Cole's, " "
2 " "	22.8±0.4	19.0±0.3	14.1±0.3	12.4±0.1	.70±.02	.36±.01	.96±.02	.56±.03	42	1.00	Crosby Bros., Topeka "
3 Sharkskin	50.9±0.2	36.6±4.8	22.4±0.3	20.9±2.8	.50±.00	.62±.06	.74±.01	.58±.05	38	0.59	Montgomery Ward Co, Manhattan, Ks.
4 Flat crepe	20.7±0.1	14.6±0.5	13.8±0.1	7.5±0.3	.48±.02	.34±.02	.67±.01	.56±.03	42	0.98	Cole's, " "
5 Sharkskin	31.8±1.5	22.3±0.2	20.2±0.7	14.9±0.1	.41±.04	.53±.02	.60±.56	.95±.01	42	1.00	Geo. Innis, Wichita, Kansas
Viscose (Spun)											
1 Shantung	31.9±0.4	32.0±0.6	15.9±0.5	13.5±0.4	.43±.01	.55±.01	.55±.01	.60±.02	39	1.49	Junkins, Topeka, Kansas
2 "	31.5±0.4	43.2±0.5	12.0±0.6	22.0±0.3	.43±.01	.60±.01	.49±.01	.59±.01	39	0.79	" " "
3 "	34.1±0.4	26.6±0.4	14.5±0.4	10.1±0.2	.38±.01	.50±.01	.44±.01	.57±.01	38	0.79	Sears, Roebuck, Topeka, Kansas
4 Dress fabric	39.5±1.0	37.3±0.6	19.1±0.5	19.6±0.6	.49±.01	.57±.01	.51±.01	.80±.02	39	0.89	Cole's, Junction City, "
5 " "	53.2±0.5	40.9±1.3	30.1±0.6	19.9±0.6	.47±.53	.54±.01	.56±.01	.54±.01	37½	0.89	John Taylor's, Kansas City, Mo.

Table 2. Percentage of shrinkage of five groups of fabrics after one to five launderings pressed with no tension, one-half, one, three and four pounds tensions.

Launderings: 1

Fabrics	0 Warp	0 Filling	1/2 Warp	1/2 Filling	1 Warp	1 Filling	3 Warp	3 Filling	4 Warp	4 Filling
Cotton										
1 Batiste	2.8	2.7	3.1	2.8	3.0	2.2	2.6	1.0	2.1	0.6
2 Cambric	5.2	3.6	5.0	3.5	5.0	2.8	4.5	2.0	4.6	0.3
3 Chambray	1.1	4.0	1.4	4.3	1.1	3.0	1.2	-0.3	1.2	-0.7
4 Percale	3.7	5.3	4.1	5.1	4.1	3.8	3.6	2.6	3.4	-0.5
5 Print	3.1	1.1	3.0	1.1	3.0	0.2	3.0	-0.3	3.0	-1.1
Linen										
1 Dress linen	1.1	1.6	1.1	0.8	1.0	0.7	1.1	-0.4	1.4	-1.0
2 " "	1.9	1.6	2.0	1.0	1.6	3.9	1.8	-0.8	2.0	-1.3
3 " "	5.8	3.3	4.4	1.7	3.5	1.6	2.8	-0.3	3.5	-2.1
4 " "	3.2	0.5	2.5	-0.4	1.8	-0.4	1.9	-1.7	2.0	-2.5
5 Unbleached	6.1	9.6	4.0	8.0	4.0	7.8	2.6	7.1	1.3	6.4
Viscose (continuous filament)										
1 Flat crepe	3.5	-2.1	3.5	-2.6	3.2	-2.8	3.2	-3.7	2.5	-3.6
2 " "	2.9	-0.4	2.0	-2.2	1.9	-1.8	1.5	2.6	0.3	-2.5
3 " "	2.1	-0.4	2.0	-1.1	1.7	-0.8	1.5	1.7	0.5	1.5
4 " "	2.8	2.9	1.7	-0.5	1.7	-0.6	0.5	-1.0	-0.7	-1.2
5 " "	3.3	-0.9	2.8	-1.2	3.0	-1.1	2.8	-2.5	1.1	-2.1
Acetate (continuous filament)										
1 Flat crepe	1.8	0.6	1.7	0.5	1.5	0.5	0.9	-0.5	0.9	-0.6
2 " "	-1.1	-1.0	-0.4	-0.6	-0.4	-1.2	-1.4	-2.5	-1.5	-2.2
3 Sharkskin	0.8	3.7	1.8	3.2	2.3	2.8	1.8	1.4	1.6	1.1
4 Flat crepe	1.2	0.4	1.5	1.1	1.5	-0.4	0.5	-1.5	0.6	1.7
5 Sharkskin	1.6	1.5	2.0	1.5	2.3	1.4	2.4	0.0	2.8	-1.0
Viscose (spun)										
1 Shantung	9.5	8.4	7.8	7.7	7.8	5.8	5.0	0.7	4.5	0.7
2 "	9.0	-0.4	7.7	-0.1	7.5	-1.6	4.2	-2.1	3.8	-3.6
3 "	9.9	7.1	8.2	4.5	7.7	4.2	5.9	0.1	4.7	-1.1
4 Dress fabric	9.7	6.1	9.8	5.5	9.0	5.2	6.6	2.7	4.4	0.1
5 " "	4.4	3.3	3.5	1.8	4.1	2.2	3.0	1.2	1.5	1.8

Launderings: 2

Fabrics	0 Warp	0 Filling	1/2 Warp	1/2 Filling	1 Warp	1 Filling	3 Warp	3 Filling	4 Warp	4 Filling
Cotton										
1 Batiste	3.5	2.7	3.4	2.1	3.3	1.5	3.1	0.9	3.0	0.0
2 Cambric	5.3	3.5	5.6	3.0	5.4	3.1	5.4	1.3	5.3	1.6
3 Chambray	1.9	3.4	1.4	2.4	1.7	1.5	0.9	1.2	1.5	0.4
4 Percale	5.0	4.4	5.0	4.0	5.0	2.8	4.6	2.4	5.1	0.6
5 Print	4.1	1.5	3.8	0.0	3.5	-0.1	3.3	-0.6	3.7	-1.3
Linen										
1 Dress linen	1.8	2.0	1.8	0.5	1.3	1.0	1.2	0.1	1.1	-0.8
2 " "	3.1	2.6	2.3	0.2	2.3	-0.2	1.6	-0.2	1.0	-0.0
3 " "	5.1	1.3	4.5	1.0	4.2	-0.6	3.2	-0.1	2.6	-0.4
4 " "	3.4	0.1	3.0	-0.9	2.6	-0.9	2.8	-1.7	1.5	-0.9
5 Unbleached	4.4	10.1	3.7	8.7	3.3	7.9	2.5	7.5	3.3	6.8
Viscose (continuous filament)										
1 Flat crepe	4.8	-1.3	4.3	-3.1	3.5	-2.9	3.0	-2.9	2.3	-3.6
2 " "	3.7	-0.7	2.5	-1.6	1.5	-1.9	1.1	-2.7	1.0	-2.5
3 " "	2.9	-0.3	2.2	-1.4	2.3	-1.4	2.1	-2.2	1.4	-2.4
4 " "	3.0	0.4	1.3	-0.7	1.2	-1.1	0.4	-1.4	0.4	-1.8
5 " "	4.9	-0.3	3.8	-1.5	3.1	1.9	2.2	-2.1	2.8	-3.0
Acetate (continuous filament)										
1 Flat crepe	2.0	0.3	2.3	0.7	0.9	0.0	0.9	-0.7	-0.4	-0.2
2 " "	-0.2	-1.9	-0.2	-1.3	-0.6	-1.9	-1.3	-2.4	-2.0	-2.6
3 Sharkskin	2.1	1.3	2.7	2.1	2.3	0.4	2.2	-0.4	2.8	-1.5
4 Flat crepe	1.7	1.2	1.5	-1.3	1.7	-1.2	2.2	-2.5	2.1	-3.3
5 Sharkskin	3.6	0.5	5.2	0.0	3.5	0.6	3.0	-0.7	3.0	-2.1
Viscose (spun)										
1 Shantung	8.9	7.0	7.5	4.7	7.9	4.5	5.5	1.4	5.1	0.9
2 "	10.1	-1.0	8.3	-1.2	7.7	-1.8	5.3	-1.8	4.7	-2.0
3 "	9.7	6.0	8.3	4.2	8.1	3.3	6.3	-0.2	7.1	-1.1
4 Dress fabric	11.2	5.9	7.5	5.3	9.2	4.1	6.7	1.1	7.9	0.4
5 " "	5.5	3.0	5.6	2.7	6.5	1.5	4.3	1.7	3.5	-0.6

Launderings: 3

Fabrics	0 Warp	0 Filling	1/2 Warp	1/2 Filling	1 Warp	1 Filling	3 Warp	3 Filling	4 Warp	4 Filling
Cotton										
1 Batiste	3.6	2.6	3.3	1.7	3.7	1.1	3.8	0.3	2.6	1.2
2 Cambric	5.9	2.5	5.7	2.3	5.7	2.4	5.1	2.3	4.8	2.1
3 Chambray	2.4	2.8	2.0	1.7	2.1	1.3	1.5	1.8	1.5	0.3
4 Percale	5.5	3.9	5.7	3.3	5.7	3.6	4.9	3.0	5.4	0.5
5 Print	4.1	1.0	4.0	0.0	3.9	0.0	4.1	-0.6	3.9	-1.3
Linen										
1 Dress linen	1.8	1.8	1.5	1.0	1.3	1.0	1.0	1.3	2.0	-0.2
2 " "	2.3	0.6	2.3	0.3	2.4	0.2	2.6	-0.4	2.1	-0.2
3 " "	5.9	0.8	4.5	0.0	4.3	-0.1	4.1	-1.4	2.2	-0.1
4 " "	3.4	-0.6	3.0	-0.6	2.6	-0.5	3.1	-1.9	2.5	-2.0
5 Unbleached	4.4	9.8	3.3	8.6	2.9	8.7	3.6	6.2	3.3	4.2
Viscose (continuous filament)										
1 Flat crepe	3.3	-2.1	5.5	-2.5	5.1	-2.6	3.8	-4.0	1.8	-2.4
2 " "	3.6	-1.0	2.1	-2.1	0.9	-2.2	0.8	-2.9	1.5	-2.8
3 " "	3.1	-0.4	2.3	-1.4	2.4	-1.5	1.8	-2.4	1.8	-2.3
4 " "	2.6	0.0	1.1	-0.5	0.8	-1.0	0.0	-1.3	-1.1	-2.4
5 " "	4.5	0.0	3.1	-1.5	3.0	-2.5	3.5	-3.5	2.9	-2.6
Acetate (continuous filament)										
1 Flat crepe	1.7	0.4	1.3	0.0	1.0	-0.4	0.6	-0.9	0.4	-1.1
2 " "	-1.0	-2.6	-0.8	-2.1	-1.2	-2.1	-1.4	-2.0	-2.2	-3.1
3 Sharkskin	3.2	0.2	3.0	-0.6	2.7	-0.6	2.4	-0.6	2.3	-1.5
4 Flat crepe	2.6	2.0	2.2	2.1	2.2	2.1	1.8	1.9	1.3	-2.5
5 Sharkskin	3.8	0.6	4.2	0.5	4.2	1.3	3.3	-0.4	2.9	-0.6
Viscose (spun)										
1 Shantung	9.3	7.3	8.6	5.0	7.3	4.7	7.1	0.3	7.1	0.1
2 "	10.3	-0.8	8.6	-1.8	9.0	-1.5	4.4	-1.5	4.2	-1.8
3 "	9.3	5.9	8.1	4.5	8.7	3.7	7.0	0.3	8.1	1.2
4 Dress fabric	10.9	7.0	9.5	4.9	9.5	4.7	8.0	1.9	4.2	-1.0
5 " "	7.2	3.3	7.0	2.6	5.8	2.6	5.0	0.8	4.4	1.0

Launderings: 4

Fabrics	0 Warp	0 Filling	1/2 Warp	1/2 Filling	1 Warp	1 Filling	3 Warp	3 Filling	4 Warp	4 Filling
Cotton										
1 Batiste	3.6	2.0	3.7	1.8	3.9	1.2	3.7	0.4	3.9	0.5
2 Cambric	6.0	3.0	5.9	1.9	5.9	2.1	5.5	1.2	5.5	-0.1
3 Chambray	2.3	2.3	2.1	2.2	2.2	2.2	1.6	0.8	1.8	-0.5
4 Percale	5.8	3.5	5.9	3.3	5.8	3.2	5.8	1.3	5.5	1.2
5 Print	4.7	0.3	4.7	0.3	3.6	0.3	3.7	-0.3	3.3	-0.7
Linen										
1 Dress linen	1.9	1.7	1.5	1.3	1.6	1.1	1.3	0.3	0.3	0.4
2 " "	3.0	0.1	2.8	0.0	2.4	0.2	2.6	0.3	1.8	0.3
3 " "	5.0	1.0	4.3	0.1	4.1	0.2	3.7	-1.1	2.8	-1.3
4 " "	3.5	-0.9	2.9	-0.7	2.9	-0.8	2.5	-1.7	1.9	-1.8
5 Unbleached	4.9	9.7	3.9	8.3	3.3	8.0	2.3	7.1	2.1	6.7
Viscose (continuous filament)										
1 Flat crepe	3.5	-2.0	3.7	-2.3	3.0	-2.8	2.9	-2.9	2.6	-3.3
2 " "	4.3	-1.9	2.5	-2.0	2.2	-2.3	0.8	-1.7	1.4	-2.7
3 " "	4.3	-1.5	2.8	-1.3	1.1	-1.3	1.9	-1.9	1.6	-2.4
4 " "	1.8	-0.2	1.4	-0.9	2.1	-1.5	-0.1	-1.7	-0.2	-1.3
5 " "	3.5	-1.3	3.4	-1.4	3.6	-2.3	2.9	-2.9	2.9	-2.9
Acetate (continuous filament)										
1 Flat crepe	1.6	0.0	1.5	-1.3	1.3	-1.5	1.7	-0.2	0.8	-1.9
2 " "	-1.0	-1.7	-2.0	-2.4	-2.0	-2.3	-2.0	-2.4	-2.7	-3.2
3 Sharkskin	2.7	0.1	2.9	-1.0	3.3	-1.9	3.4	-2.4	2.9	-2.7
4 Flat crepe	2.4	-1.6	2.3	-1.6	2.8	-1.5	1.3	-3.1	2.6	-2.6
5 Sharkskin	3.5	0.0	3.9	0.0	3.1	-0.3	2.7	-0.5	2.6	-0.9
Viscose (spun)										
1 Shantung	8.0	6.3	8.0	5.1	7.1	5.1	6.0	3.0	4.6	2.5
2 "	8.9	-0.6	7.7	-0.9	8.8	-1.6	7.5	-2.3	4.9	-2.1
3 "	9.4	4.0	9.1	4.3	8.1	4.6	8.0	1.6	6.5	0.0
4 Dress fabric	11.0	5.8	10.8	5.9	9.7	5.4	7.8	1.4	6.3	1.6
5 " "	8.4	2.9	7.0	3.3	7.1	3.3	5.6	1.1	4.7	-0.2

Launderings: 5

Fabrics	0 Warp	0 Filling	1/2 Warp	1/2 Filling	1 Warp	1 Filling	3 Warp	3 Filling	4 Warp	4 Filling	Total
Cotton											
1 Batiste	3.5	2.4	3.7	1.3	3.8	1.8	3.5	0.2	3.0	0.1	
2 Cambric	6.2	2.8	5.8	2.3	5.9	1.9	5.2	2.5	5.1	0.7	
3 Chambray	2.9	2.8	2.0	1.7	1.8	2.1	1.5	0.3	1.6	-0.2	
4 Percale	6.4	3.8	6.2	3.3	6.1	2.9	5.5	1.4	5.2	0.9	
5 Print	4.8	0.8	4.5	0.5	4.1	0.4	3.9	-0.3	2.5	-0.7	684.0
Linen											
1 Dress linen	2.0	1.6	2.4	0.8	1.6	0.9	1.5	0.7	1.6	0.5	
2 " "	3.0	1.0	2.5	0.6	2.7	0.1	1.9	-0.3	2.3	-0.4	
3 " "	5.3	0.6	4.2	0.1	4.0	0.0	2.8	-1.2	2.5	-1.2	
4 " "	3.6	0.0	3.2	-0.2	2.8	-0.6	3.5	-2.0	2.4	-1.7	
5 Unbleached	4.7	9.2	3.3	8.9	3.2	8.0	2.2	6.9	2.2	6.0	546.2
Viscose (continuous filament)											
1 Flat crepe	5.1	-2.6	3.6	-3.0	3.5	-2.7	2.8	-3.7	2.4	-3.0	
2 " "	3.4	-1.7	2.3	-2.6	2.8	-2.2	0.8	-2.5	1.5	-2.0	
3 " "	3.9	-0.3	2.3	-2.0	2.7	-1.6	0.8	-1.5	1.1	-2.2	
4 " "	1.7	-0.4	1.4	-1.3	1.4	-1.1	0.1	-1.6	0.1	-1.3	
5 " "	5.0	-1.6	3.0	-2.7	3.6	-2.0	2.2	-2.4	3.5	-3.1	75.5
Acetate (continuous filament)											
1 Flat crepe	2.2	-1.2	1.7	-0.6	2.4	0.4	0.6	-0.9	0.7	-0.5	
2 " "	-1.1	-2.7	-3.0	-2.5	-1.9	-2.2	-2.9	-2.8	-3.2	-2.1	
3 Sharkskin	3.5	-0.9	2.9	-1.6	3.1	-1.1	2.3	-2.6	1.6	-2.4	
4 Flat crepe	2.8	-2.4	2.9	-1.6	3.7	-0.6	1.8	-2.4	1.8	-2.8	
5 Sharkskin	3.6	-0.5	3.5	-0.3	3.6	0.1	3.5	-1.3	3.4	-2.2	93.7
Viscose (spun)											
1 Shantung	9.8	6.6	8.1	5.1	6.7	5.6	5.6	2.6	5.0	2.1	
2 "	10.0	-0.8	8.0	-1.4	7.9	-1.3	6.1	-2.1	5.2	-2.7	
3 "	10.2	4.5	8.9	4.5	9.1	4.0	7.9	2.1	7.0	0.0	
4 Dress fabric	11.4	7.1	10.1	4.2	9.7	5.3	6.5	2.3	6.6	2.0	
5 " "	7.8	3.3	8.1	3.4	7.7	2.2	6.5	1.0	5.7	-0.2	1193.3

	Launderings 1	Launderings 2	Launderings 3	Launderings 4	Launderings 5
Laundering totals:	517.0	516.5	530.4	512.0	516.8
Tension totals:	0 pounds - 776.5	1/2 pound - 623.2	1 pound - 584.3	3 pounds - 359.7	4 pounds - 249.0

Warp total: 2217.0
Filling total: 375.7
Sum of squares: 16765.93

Total 2592.7

Table 3. Means of percentage of shrinkage for fabrics after launderings with tensions and in warp and filling.

Fabrics	Launderings 1	2	3	4	5	Mean	Tensions (lbs.) 0	½	1	3	4	Mean	Warp	Filling	Mean
Cotton	2.5	2.7	2.8	2.8	2.8	2.7	3.4	3.1	2.9	2.3	1.8	2.7	3.9	1.6	2.7
Linen	2.2	2.2	2.2	2.2	2.2	2.2	3.2	2.5	2.3	1.6	1.3	2.2	2.7	1.6	2.2
Viscose (continuous filament)	0.5	0.4	0.2	0.2	0.2	0.3	1.3	0.4	0.3	-0.1	-0.4	0.4	2.3	-1.7	0.3
Acetate (continuous filament)	0.7	0.4	0.6	0.0	0.0	0.3	0.8	0.7	0.7	0.0	-0.3	0.4	1.5	-0.7	0.4
Viscose (spun)	4.4	4.5	4.8	5.0	5.1	4.8	6.7	5.7	5.4	3.4	2.6	4.8	7.3	2.2	5.0

The sum of squares was calculated by the following method:

Correction term: $C = \frac{(SX)^2}{n} - \frac{(2592.7)^2}{1250.0} = 5377.67$ in which X is the result of any one test and n the number of tests.

Total: $SX - C^2 = 16765.93 - C - 11388.26$

Fabrics: $\frac{(684.0)^2}{250.0} + \frac{(546.2)^2}{250.0} + \frac{(75.5)^2}{250.0} + \frac{(93.7)^2}{250.0} + \frac{(1193.3)^2}{250.0} - C = 3440.87$

Launderings: $\frac{(517.0)^2}{250.0} + \frac{(516.5)^2}{250.0} + \frac{(530.4)^2}{250.0} + \frac{(512.0)^2}{250.0} + \frac{(516.8)^2}{250.0} - C = 00.77$

Tensions: $\frac{(776.5)^2}{250.0} + \frac{(623.2)^2}{250.0} + \frac{(584.3)^2}{250.0} + \frac{(359.7)^2}{250.0} + \frac{(249.0)^2}{250.0} - C = 718.82$

Warp vs. filling: $\frac{(2217.0)^2}{625.0} + \frac{(375.7)^2}{625.0} - C = 2712.31$

Fabrics x launderings: $\frac{443239.45}{50.00} - C = 3487.11 - 3441.64 = 45.47$

Fabrics x tensions: $\frac{487452.23}{50.00} - C = 4371.37 - 4159.69 = 211.68$

Fabrics x warp vs. filling: $\frac{1518442.91}{125.00} - C = 6769.87 - 6153.18 = 616.69$

Laundry x tensions: $\frac{305467.41}{50.00} - C = 731.68 - 719.59 = 12.09$

Laundry x warp vs. filling: $\frac{1022614.03}{125.00} - C - 2803.24 - 2713.08 = 90.16$

Tension x warp vs. filling: $\frac{1103553.21}{125.00} - C - 3450.75 - 3431.13 = 19.62$

Samples within fabrics (variation within a group):

Correction term: $C\ (\text{cotton}) = \frac{(684.0)^2}{250.0} = 1871.42$

$$\frac{(118.3)^2+(190.1)^2+(83.5)^2+(198.6)^2+(93.5)^2}{50.0} = \frac{105289.36-C\ (\text{cotton})}{50.00} = 2105.78-1871.42 = 234.36$$

Correction term: $C\ (\text{linen}) = \frac{(546.2)^2}{250.0} = 1193.33$

$$\frac{(54.9)^2+(65.5)^2+(101.1)^2+(43.7)^2+(281.0)^2}{50.0} = \frac{98386.16-C\ (\text{linen})}{50.00} = 1967.92-1193.33 = 774.59$$

Correction term: $C\ (\text{c.f.viscose})^* = \frac{(75.5)^2}{250.0} = 22.80$

$$\frac{(11.9)^2+(3.0)^2+(21.8)^2+(3.9)^2+(34.9)^2}{50.0} = \frac{1859.07-C\ (\text{c.f.viscose})}{50.00} = 37.18-22.80 = 14.38$$

Correction term: $C\ (\text{c.f.acetate})^{**} = \frac{(93.7)^2}{250.0} = 35.11$

$$\frac{(22.9)^2+(-91.3)^2+(57.1)^2+(28.6)^2+(76.4)^2}{50.0} = \frac{18775.43-C\ (\text{c.f.acetate})}{50.00} = 375.50-35.11 = 340.39$$

Correction term: $C\ (\text{spun viscose}) = \frac{(1193.3)^2}{250.0} = 5695.85$

$$\frac{(281.0)^2+(141.0)^2+(273.5)^2+(308.9)^2+(188.9)^2}{50.0} = \frac{304746.67-C\ (\text{spun viscose})}{50.00} = 8094.93-5695.85=399.08$$

Sum of squares for samples within fabrics:

$234.36+774.59+14.38+340.39+399.08 = 1762.80$

*Continuous filament viscose
**Continuous filament acetate

In obtaining the error term for the samples within fabrics in Table 4, the remainder was used. Because the probability was $\ll .001$, samples within fabrics was used as the error term for all interactions. No significant interactions were found. Thus samples within fabrics was also used as the error term for the main effects, i.e., fabrics, launderings, tensions, warp vs. filling. In the main effects, as shown by Table 4, significant differences were found for fabrics and for warp vs. filling. The shrinkage in the warp was considerably greater than in the filling.

By using individual degrees of freedom, as shown in Table 4, cotton and linen were compared with continuous filament viscose rayon and continuous filament acetate rayon, and cotton was compared with spun viscose rayon.

Sum of squares of cotton + linen vs. continuous filament viscose rayon and continuous filament acetate rayon:

$$\frac{(684.0-546.2) - (75.5-93.7)^2}{4(250.0)} = 1125.72$$

Sum of squares of spun viscose rayon vs. cotton:

$$\frac{(1193.3-684.)^2}{2(250)} = 518.77$$

Samples within fabrics was again used for the error term. The probabilities of $< .01$ and $< .05$ showed significant differences between these two groups. It was found that the continuous filament viscose rayon and continuous filament acetate rayon shrank less than cotton and linen. The spun viscose rayon shrank more than cotton.

Table 4. Analysis of variance of shrinkage of cotton, linen and rayon fabrics.

Source of variation	Degrees of freedom	Mean square	F*	Probability
Fabrics (cotton, linen, c.f. viscose, c.f. acetate and spun viscose)	4	860.21	9.76	.001
[Cotton + linen vs. c.f. viscose + c.f. acetate	[1	[1125.72	[12.77	[.01
Spun viscose vs. cotton	1	518.77	5.77	.05
Remainder]	2]	898.19]	10.19]	.001]
Launderings (1,2,3,4,5)	4	.19	.002	
Tensions (0, $\frac{1}{2}$, 1, 3, 4 lbs.)	4	179.70	2.04	.15
Warp vs. filling	1	2712.31	30.77	.001
Fabrics x launderings	16	2.84	.032	
Fabrics x tensions	16	13.23	.150	
Fabrics x warp vs. filling	4	154.17	1.749	
Launderings x tension	16	.75	.008	
Launderings x warp vs. filling	4	22.54	.255	
Tensions x warp vs. filling	4	4.90	.055	
Samples within fabrics	20	88.14	58.37	.001
Remainder	1156	1.51		
Total	1249			

*Error term : 88.14

Successive launderings did not significantly increase the shrinkage. Differences between tensions failed to be significant in comparison with variability of samples within fabrics.

Shrinkage of a Representative Fabric in Each Group

Figure I shows the graphs of shrinkage after five launderings of one representative fabric from each group pressed under various tensions. Curves for successive launderings were in most cases overlapping and their order changed from fabric to fabric. Consequently the shrinkage due to successive launderings was negligible. The curves for the warp of cotton and linen were nearly horizontal which indicated that tensions had little effect on shrinkage of these fabrics. On the other hand, the curves for spun viscose rayon, in both warp and filling were comparatively steep. This is evidence that tension decreased and the shrinkage of spun viscose rayon fabrics more than it did the shrinkage of other fabrics, even though this lacks substantiation by analysis of variance.

Dimensional Restorability of Fabrics Tested

Twelve fabrics were found to be restored to within ±2.0 per cent of the original dimensions in the warpwise direction. Of these one was restored with one-half pound tension, one with one pound tension, six with three pounds tension and four with four pounds tension.

Thirteen fabrics were found to be restored to within ±2.0 per cent of the original dimensions in the fillingwise direction.

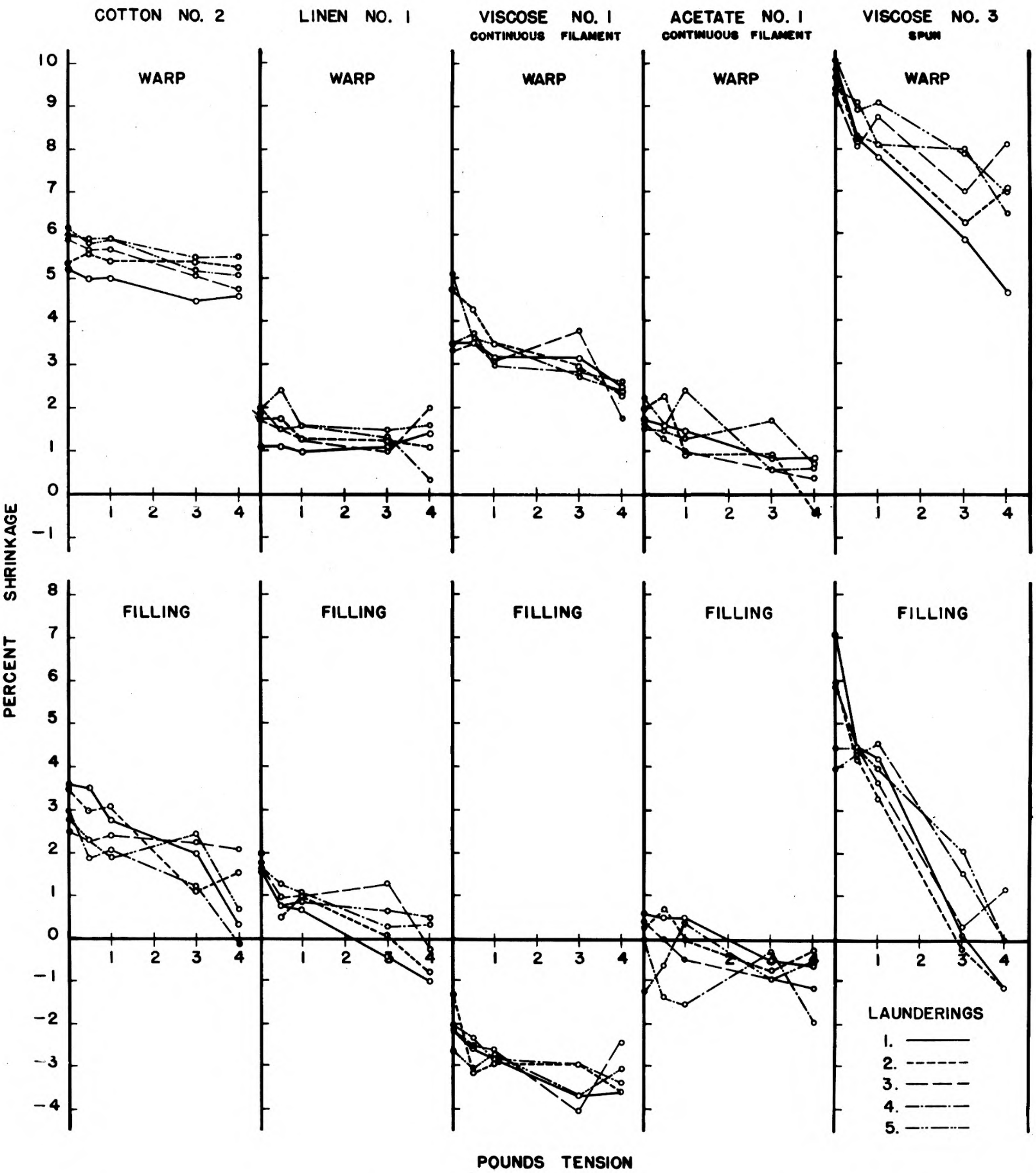


FIG. 1. SHRINKAGE OF FABRICS AFTER LAUNDERINGS PRESSED UNDER VARIOUS TENSIONS.

Of these, four fabrics were restored without any tension to and including four pounds tension, two fabrics were restored without any tension to and including three pounds tension, three fabrics were restored without any tension to and including one pound tension, three fabrics were restored with three and four pounds tension and one fabric with one, three and four pounds tension.

Only three fabrics were dimensionally restored in both warp and filling. Two of these were cotton and one was linen.

All of the cotton specimens were dimensionally restored in the filling, but two were dimensionally restored in the warp. Three linen were dimensionally restored in the filling and three in the warp. Three continuous filament viscose rayons were dimensionally restored in the warp, but all of them stretched excessively in the filling. Two of the continuous filament acetate rayon specimens were dimensionally restored in the warp but they all stretched excessively in the filling. None of the spun viscose rayons were dimensionally restored in the warp but four were in the filling.

SUMMARY AND CONCLUSIONS

This study was made to compare the shrinkage, due to laundering of cotton, linen, and rayon fabrics pressed under controlled tensions. Shrinkage was recorded after pressing without tension, with one-half, one, three and four pounds tension, successively applied, and after five launderings.

Significant differences were found in shrinkage between the groups of fabrics and for samples within fabrics.

Significant differences in shrinkage were found between the warp and filling of fabrics. The shrinkage in the warp was considerably greater than shrinkage in the filling. The shrinkage of the cotton in the warp after the first launderings ranged from 1.1 to 5.2 per cent; the linen from 1.1 to 6.1 per cent; continuous filament viscose rayon from 2.1 to 3.5 per cent; continuous filament acetate rayon from -1.1 to 1.8 per cent and the spun viscose rayon from 4.4 to 9.9 per cent.

Successive launderings did not increase shrinkage significantly. The difference between tensions failed to be significant in comparison with the variability of samples within fabrics.

The continuous filament viscose rayon and continuous filament acetate rayon shrank less than cotton and linen, but the spun viscose rayon shrank more than cotton.

On the graphs showing shrinkage of one representative fabric in each group, the comparatively steep curves for spun viscose rayon presented evidence that tension decreased shrinkage of fabrics made of spun viscose more than it did the shrinkage of other fabrics, even though this was not substantiated by the statistical analysis.

Only three of the 25 fabrics studied were dimensionally restored in the warp and filling to within ±2.0 per cent of the original dimensions, measured after pressing with the flat-bed press. Of the three fabrics dimensionally restored in warp and filling, two were cotton and one was linen.

Cotton was dimensionally restorable in the filling, but some specimens were not restorable in the warp. Linen was not frequently restored in either warp or filling. Some of the continuous filament rayons, both viscose and acetate, were dimensionally restored in the warp, but all stretched excessively in the filling. The spun viscose rayons were dimensionally restorable in the filling, with the exception of one, but not restorable in the warp.

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