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SOME EFFECTS OF WARP TENSION
ON FABRIC PROPERTIES

A THESIS

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the Faculty of the Graduate Division

by

Robert Bryans Watkins

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ON FABRIC PROPERTIES

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SUMMARY

Experiments on yarn tensions in the weaving process have thus far been insufficient to establish the extent of the effects of varying warp tensions on fabric properties. The primary reason for this insufficiency is that most experiments have been done with the material in the greige state, only, rather than having a portion of it Sanforized.

The purpose of this study was to investigate the effects of varying warp tensions on fabric properties. The cotton yarns used were the same as those normally used by a mill in the production of a style for commercial use. The weaves used were a 2/2 right-hand twill and a 2/2 left-hand twill; the warp contained 2864 ends; counts of the warp yarns were 14.75's and the counts of the filling yarns were 15.50's.

The filling tension was held constant, and the warp tensions used were 40, 50, 60, and 70 grams. Both greige and Sanforized samples were produced. The Sanforized samples had been designed and bleached before being put through the standard Sanforizing process. The Draper Model XD loom used was equipped with a Bartlett let-off motion, a 20 harness dobby and a Unifil winding attachment. For measuring the tension a Uster Custom Tension Recordograph was used.

It was found that the width of the cloth decreased, the ends and picks increased, and air permeability decreased, with an increase in tension. Single yarns in the greige state decreased in breaking strength, warp crimp in the greige state decreased, and filling crimp in both the greige and Sanforized states increased. Furthermore, both warp breaking

strength in the greige for ravelled strip breaks and, warp shrinkage in the greige state increased, whereas, filling shrinkage in the greige state was unaffected.

The phenomenon wherein the breaking strength increases with an increase in tension for the ravelled strip method, but decreases for the single yarns could be investigated further for other weaves and yarn counts. The relationship of air permeability to ends per inch and picks per inch for various weaves warrant further investigation.

CHAPTER I

INTRODUCTION

A considerable amount of theorizing about and experimenting with fabrics in the greige state has been done. However, experiments to correlate the effects of weaving tensions on the cloth in the greige state with regard to the finished cloth have been very few and sometimes inconsistent.

Knight (1) compared the strength, width, construction, crimp, shrinkage, and bow of a fabric woven under different controlled tensions in both the greige state and in the Sanforized state. Knight's outstanding finding was the effect of yarn tensions in the weaving process on the breaking strength of the woven fabric (2). With the higher warp tensions used, the breaking strength was less (than with the lower tensions) while the cloth was in the greige state; but the breaking strength for the cloth was higher while the cloth was in the Sanforized state.

The tests made by Knight were with a sports denim. Knight states in his summary:

> It should be kept in mind that this study covered only one fabric made from a three harness twill weave. Variations in yarn counts, constructions, and weave would certainly have varying effects on fabric characteristics. It would be enlightening to carry this study further in an effort to establish the extent of these variations.

F. T. Pierce (3) says that features relating to the physical causes of shrinkage may be usefully evaluated. He suggests that yarn tensions in weaving or finishing may be the primary causes of instability of dimensions. He also says that the structure of the cloth from the loom is practically determined by the almost constant filling crimp and the yarn diameters, whereas very different crimp changes may be expected when the cloth is processed. In wetting and drying, an elastic balance tends to take place.

According to G. E. Collins (4) the large shrinkages that can occur with cotton fabrics must be due to some feature or features peculiar to the fabrics themselves. He states that both cotton fibers and yarns in themselves can show at most a shrinkage of a few percent.

Morton and Williamson (5) mention that the relative values assigned to the yarn tensions provide an interesting field for further study. They say that the tensions are such as to make the fabric contract both in the direction of the warp and in the direction of the filling as soon as all external restriction has been removed. The changes in dimensions of the cloth on the loom are noted. The picks are found to be closest together at the fell of the cloth, then to pull apart near the cloth roller and to close in again following the cloth roller. When the cloth is removed from the loom, the cloth is free to ease itself of the strain on the warp ends by contracting, so the picks per inch increase further.

Morton and Williamson (6) claim, further, that the ends per inch in the cloth are greater after it leaves the sandroll than at the reed, as would be expected. However, due to an interaction of forces between the warp and the filling, the picks per inch are never so great as at the fell of the cloth.

D. C. Snowden (7) finds little difference in the width of fabrics woven at high and at low warp tensions upon removal from the loom. On desizing, the difference in fabric width is only slightly evident. The relaxation of the fabric upon being removed from the loom decreases the length with a corresponding increase in picks per inch. Snowden says that with greater warp tension, the warp threads crimp less at the fell and probably crimp the filling yarns and cause them to crimp more. As a result of the high tension, the goods upon being desized, show less effect on the crimp than that resulting from normal relaxation in the greige state.

According to Snowden (8) increasing the warp tension has little effect on bursting strength, ravelled strip breaking strength, and air permeability. However, he does not state what tensions were used and his results differ from those obtained by Knight (9) - particularly in regard to ravelled strip breaking strength.

According to F. Courtney Harwood (10) the shrinkage which commonly occurs on wetting and drying a fabric results from yarn shrinkage and increase of crimp. These two causes are intimately related. As the fibers swell, they must have more room, and the only way this can come about is by an increase in crimp. The cloth, therefore, contracts. Should the warp or filling lie unduly straight in the grey state, the strains may balance themselves by redistributing the crimp between the two sets of yarns. Such a redistribution during finishing usually indicates that one set of yarns was severely stretched in an earlier process.

Harwood states:

> Undue tensions in spinning or weaving set up latent strains in the fabric, which are released on wetting, and contribute to the total shrinkage.

As A. S. Ray (12) says, all fabrics are subject to shrinkage, the amount depending upon several factors. Among these factors are the type of fiber, the fabric structure, and the finishing processes applied. As a customer is particular about the dimensions of the fabrics, they must often be subjected to stretching both in the warp direction and in the filling direction. In cotton fabrics the most satisfactory way of solving the shrinkage problem is by using the Sanforizing process. The principle involved is that of rearranging the yarns to about the same degree as they would shorten in laundering.

Thus, the existing research discusses only in general terms the properties of fabrics as they relate to tension in weaving and to the finishing processes. The articles are concerned primarily with theories.

The purpose of this study was to carry further the work done by Knight (11), assigning specific values to the tension on the warp ends and finding the effects of tension on the various physical properties of the fabric for the weaves chosen. Some of these effects might prove sufficiently important for weaving mills to employ tension-testing devices when starting up new warps on looms. This use of the devices would be for the dual purpose of assuring uniformity of tensions in both warp and filling for the various styles being woven and for utilizing the optimum tension for each style.

The work done in this investigation was performed using four harness weaves, with selected right-hand and left-hand arrangements of patterns.

CHAPTER II

INSTRUMENTATION AND EQUIPMENT

The loom used to weave the fabric for conducting the work on this problem was a Draper Model XD, equipped with a Unifil filling winding attachment and a 20 harness dobby.

This loom was chosen largely because of the positive action of its Bartlett let-off motion. The Unifil winding attachment was used both for convenience and for the uniformity of tension with which it winds filling onto the bobbin. Double springs used on the harnesses assured positive action. Some features of the loom chosen, as brought out by Knight (11), are as follows:

Let-off - - - - - - - - -	Positive Bartlett
Take-up - - - - - - - - -	Intermittent
Sandroll Cover - - - -	Synthetic
Warp Stop Motion - - -	Electric
Filling Stop Motion - -	Center Fork
Shuttle Eye - - - - - - -	Synthetic type, Adjustable Pads
Whiproll Timing - - - -	3/4" Before Front
Harness Timing - - - -	Fell 2 1/4"
Loom Speed- - - - - - -	160 P.P.M.
Width of Loom - - - - -	46"

A shuttle with adjustable tensioning pads was chosen to permit selecting particular tensions on the filling. A yarn reel was used to give the filling a constant unwinding speed while tension was being set.

Since it was important to measure the yarn tensions as accurately as possible, an electronic device was chosen. The one selected was the Uster Custom Tension Recordograph with a 151 Sanborn Recorder equipped with a sensing head by the Custom Scientific Company. By use of the weaving attachment this device allows direct readings of the tension in grams. See pages 7, 8, and 9 for pictures of the device in operation, and of the charts produced.

The filling yarn was received on spinning bobbins; therefore, before use it had to be wound onto cones, for use with the Unifil attachment. For this operation a Leesona drum type winder was used.

For testing the crimp a Brighton Crimp Tester was used.

The air permeability was tested by use of the Frazier Air Permeability Meter.

For testing the breaking strength of the single yarns a Suter Single Yarn Break Machine with movement between the jaws of twelve inches per minute was used.

For testing thickness a Randall and Stickney Thickness Tester was used.

The one-inch warp and filling strips were tested for breaking strength with a Scott Vertical Tester with movement between jaws of twelve inches per minute.

Other miscellaneous equipment included a drawing-in rack, templates, pick glass, Smith-Drum washer, flat-bed press, and marking rule for Sanforized samples.

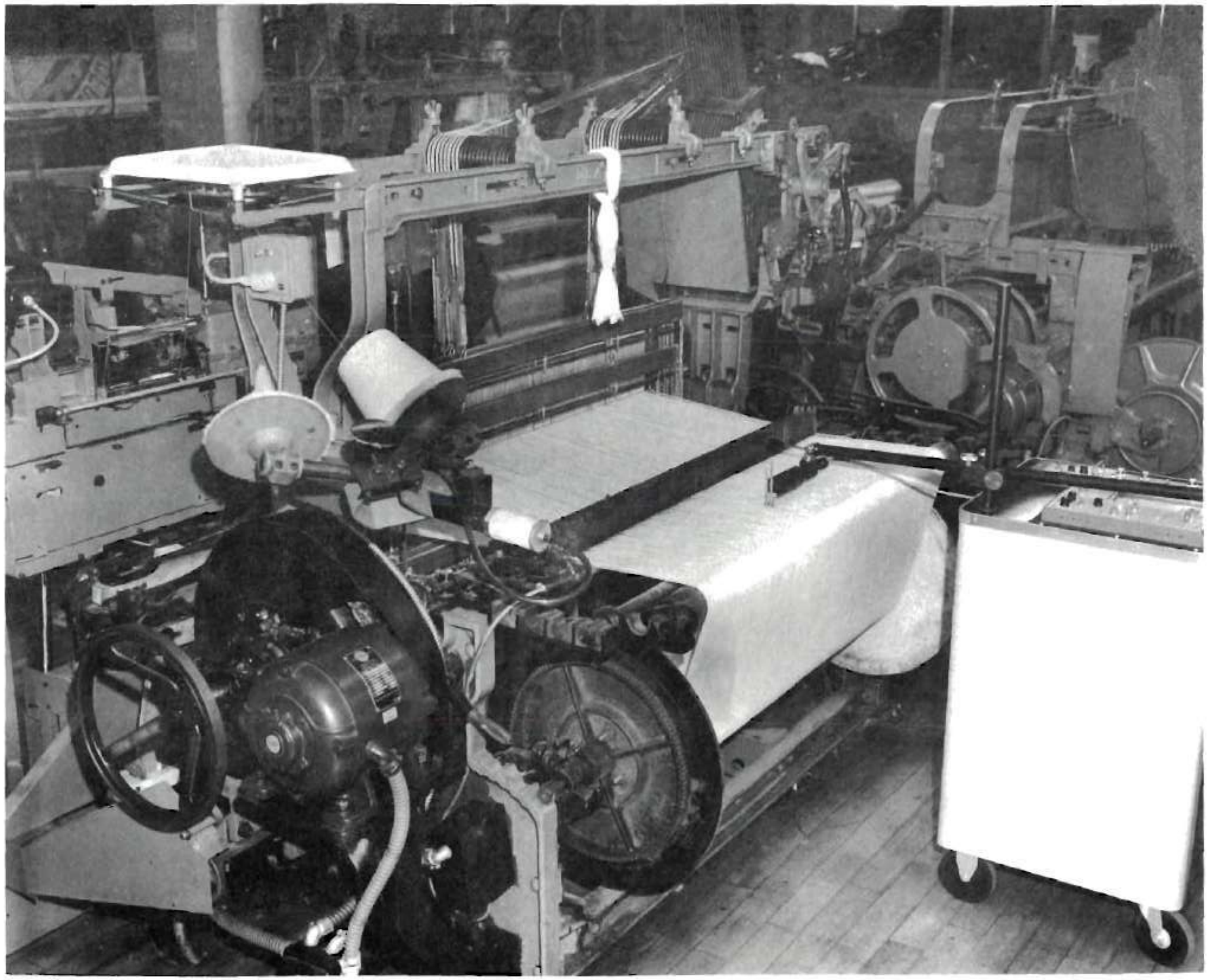

Figure 1. Uster Tension Recordograph Recording Warp Tension.

Figure 2. Uster Tension Recordograph Recording Filling Tension.

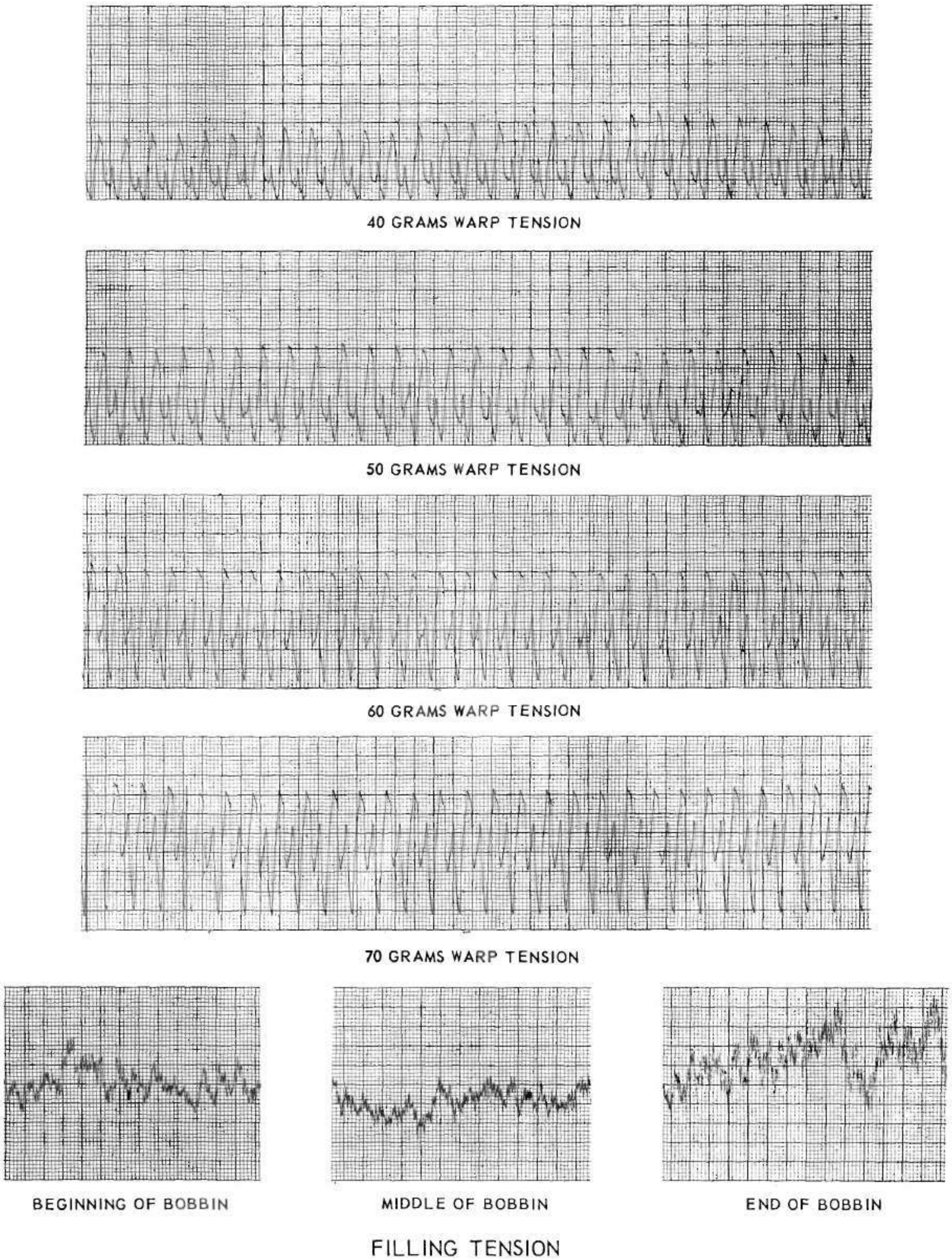

Figure 3. Tension as Recorded on the Sanborn Recorder.

CHAPTER III

PROCEDURE

The warp and the filling yarns for this experiment were furnished by the Crystal Springs Bleachery, Chickamauga, Georgia. The yarns were 14 3/4's warp counts and 15 1/4's filling counts - both cotton yarns. The warp had been sized with a standard commercial formula which this plant uses for its drill style with this combination of yarns.

The loom was set to weave a 2/2 twill and both right-hand and left-hand 2/2 twills were subsequently woven. For greige samples ten yards each at 40, 50, 60, and 70 grams were woven. For Sanforized samples twenty-five yard test specimens at each of the above tensions were woven - all in one continuous piece.

For fixing the shuttle tension the following arrangement was used to insure a constant speed in unwinding the yarn from the bobbin in the shuttle. A yarn reel 14 1/2" in diameter was set to turn at 310 R.P.M., which meant that the yarn unwound at 1178 feet per minute. The shuttle was set in a stationary position approximately five feet from the yarn reel, the yarn from the bobbin was threaded around the reel and the tension-recorder head positioned on the yarn about two feet from the shuttle. The nylon tension pads in the shuttle were adjusted to a yarn tension of 24 grams with the yarn unwinding at the speed determined by the reel.

The Uster Tension Recordograph was used for measuring the tension on the filling yarn. It was found that the shuttle tension varied from start to finish of the bobbin. It was slightly higher at the start than in the middle, and considerably higher for about the last one-fourth of the bobbin. The tension for the filling was set for the central portion of the bobbin as this represented the largest portion of yarn wound on the bobbin.

Tension for the warp yarns was set by adjustment of the Bartlett let-off motion. To guard against any variation in tension from end to end in the warp the same end was used throughout for the Recordograph.

Tension was checked as frequently as was necessary to maintain the desired tension. The two lowest tensions had a tolerance of plus or minus five grams, whenever, the two highest tensions were read within plus or minus two grams.

With the view in mind that some settling down might be necessary in the Sanforizing process, twenty-five yard samples were woven for each tension chosen for the Sanforized samples. Ten yard samples were woven for the greige.

The sanforized samples were desized and bleached prior to being put through the standard Sanforizing process by the Crystal Springs Bleachery, Chickamauga, Georgia. On the compressive shrinkage machine the Tenter was not used. This was to avoid changing the width of the material. The width was determined at five places for each sample, measured to the nearest one hundredth of an inch by use of a scale marked in tenths of an inch.

The bow was determined by tracing randomly chosen picks across the cloth with a pick glass.

The ends and picks per inch were counted at locations about evenly spaced throughout the samples. No counts were made closer than eight inches to the selvage of the cloth. Air permeability was tested at arbitrarily located places throughout the samples in the central portion of the cloth. Thickness was similarly tested.

After these tests, ten 12" x 12" pieces were cut from each sample. These were used for obtaining the yarn samples for crimp testing, single yarn break tests, and the fabric strips for the ravelled strip tests.

In checking the crimp, markings were made on the cloth eight inches apart in both the warp direction and in the filling direction. The ends and picks were then ravelled out as needed for testing. The weight of ten grams for the crimp tester was arrived at by use of the A.S.T.M. formula. The standard number, 131, is to be divided by the number of thousands of yards per pound of the yarn to be tested.

$$\frac{131 \times 1000}{15 \times 840} = 10.4$$

When testing for single yarn tensile strength, the jaws were set 10" apart. The crimp was removed by pulling lightly on the yarn with the fingers.

Strips were cut from each sample - two warpwise and two fillingwise. These were 6" long and 1 1/2" wide. They were ravelled down to 1" and tested for breaking strength and elongation. The jaws on the Scott tester were set 3 inches apart. The averages of the breaking strengths for each sample were divided by the average number of ends or picks for that sample in order to obtain the resulting breaking strength for each end or pick. This was done to permit comparing the strip breaks with the single yarn breaks.

In order to test the shrinkage three 24" x 24" pieces were cut from each sample woven at the various tensions for both greige and Sanforized samples. These pieces were cut in for about 1/2" at spacings of about three inches apart around the edges. This was done to prevent tangling of the loose threads. The pieces then were marked at five places each with 18" markings for both warp and filling. The marked pieces were then placed in a home-style washer. The washer was equipped with a manual control dial and was of the top-loading type containing a vertical paddle-type agitator. A soaking period of fifteen minutes at 140° F was carried out. The water was then drained, soap was added, and the washer was refilled with water at 200° F. After washing for forty minutes the water was drained, followed by a ten-minute rinse at 140° F and a five-minute rinse at 140° F. The pieces were then spun and removed.

The pieces were allowed to dry flat, then they were sprinkled and ironed on a flat bed press. The distances between markings were then measured and recorded.

CHAPTER IV

RESULTS

Most tests resulted in either a progressive increase or a progressive decrease in measured values for samples between forty grams and seventy grams tension. The three lowest tensions apparently showed little or no weakening of the fabric; whereas, the seventy gram tension reduced the strength in the warp direction for almost every set of samples. Apparently the seventy gram tension strained the warp yarns so much that they could not return to their original state upon release from the tension of the loom.

In many test results, there was either much greater or less variation for the sixty and seventy gram (left-hand) samples, than for the forty to sixty gram samples. In some instances the variation at this point took a direction oppostive to that encountered among the other sets of samples. This occurred in the tests for air permeability and for warp construction.

The widths showed a smooth pattern of decrease in greige and Sanforized weaves, both for the right-hand and left-hand patterns. The decrease in width from the lowest to the highest tension was approximately one-half inch. It was somewhat less in the greige than in the Sanforized.

The bow was checked in the greige samples. The amount of bow increased with the increase in tension up to a point, varying with right-hand and left-hand weaves, then decreased. The decrease in bow was

Table 1. Summary of Widths in Inches

Grams Tension	Greige		Sanforized
		Right Hand	
40	38.02		34.86
50	37.64		34.48
60	37.69		34.23
70	37.50		34.17
		Left Hand	
40	37.86		34.84
50	37.69		34.44
60	37.67		34.25
70	37.43		34.23

greater between the sixty-gram tensionsamples and the seventy-gram tension samples of the left-hand weave than between other samples with a ten gram difference in tension.

Table 2. Summary of Bow in Inches

Grams of Tension	Right Hand	Left Hand
40	.335	.365
50	.432	.417
60	.508	.402
70	.400	.262

The ends per inch of the fabric warp tension increased from the lowest to the highest tensions for both the greige and Sanforized samples for both weaves, with two exceptions. The seventy-gram samples, both greige and Sanforized, of the left-hand weave showed a decrease in ends per inch. The filling construction showed an increase in picks per inch with an increase in tension in all cases except one. The picks per inch decreased with an increase in tension from sixty grams to seventy grams for the greige sample of the right-hand weave. There was a larger than normal number of picks per inch for the seventy-gram sample of the left-hand weave compared with the sixty-gram sample.

Table 3. Summary of Fabric Construction

Grams Tension	Warp Greige Ends per Inch	Warp Sanforized Ends per Inch	Filling Greige Picks per Inch	Filling Sanforized Picks per Inch
		Right Hand		
40	73.66	80.59	57.19	62.85
50	74.78	81.56	60.39	63.80
60	74.98	82.19	60.47	64.60
70	75.62	82.56	59.97	65.61
		Left Hand		
40	74.90	81.55	57.20	62.73
50	74.98	82.25	58.79	63.81
60	75.49	82.47	59.75	64.74
70	75.41	82.09	60.63	66.56

The thickness of the griege samples of both right-hand and left-hand weaves decreased with an increase in tension. The thickness of the Sanforized samples of the right-hand weave showed no change in thickness between the forty-gram and the seventy-gram samples. The thickness of the Sanforized samples of the left-hand weave increased with an increase in tension.

Due to the number of variables entering into the air permeability

Table 4. Summary of Fabric Thickness in .001 Inches

Grams Tension	Right Hand	Left Hand
	Greige	
40	21.79	20.96
50	19.38	20.07
60	19.00	19.05
70	18.12	18.30
	Sanforized	
40	17.47	17.18
50	17.37	17.09
60	17.44	17.29
70	17.44	17.27

of a fabric (yarn counts, construction, crimp, etc.), the air flow through the samples was multiplied by the thickness of the samples to get a comparison of the effect of tension with respect to these variables. The air permeability decreased regularly with an increase in tension in all samples except one. The Sanforized sample which was woven using seventy-grams of tension and a left-hand twill weave showed more air flow than did the sixty-gram sample of this description.

Table 5. Summary of Air Flow
Thickness in .001 Inches x air Permeability in cu. ft./sq. ft. of Fabric

Grams Tension	Right Hand	Left Hand
	Greige	
40	1872	1722
50	1220	1304
60	1158	1222
70	1063	1100

Table 5. Summary of Air Flow (Continued)

Grams Tension	Right Hand	Left Hand
	Sanforized	
40	232.0	229.5
50	220.0	212.4
60	211.8	197.0
70	195.2	197.8

Warp single-strand breaks for the greige samples, decreased in strength with an increase of tension. The Sanforized samples showed, generally, an increase of strength with an increase of tension up to the sixty grams of tension. The seventy-gram Sanforized samples showed a decrease of breaking strength from the sixty-gram samples. The seventy-gram left-hand warp sample showed a greater decrease in breaking strength than did the seventy-gram right-hand sample.

The greige filling yarns showed a decrease in breaking strength from the lowest to the highest tensions except for the seventy-gram left-hand sample, which showed a marked increase. The Sanforized filling samples increased in breaking strength from the forty-gram through the sixty-gram samples. In the right-hand samples the seventy-gram sample showed a decreased in breaking strength over the sixty-gram sample. In the left-hand weave, an unexpected rise in breaking strength occurred between the sixty and seventy-gram filling samples.

The elongation in the warp yarns showed a decrease in the greige from the lowest to the highest tensions for the right-hand weave. No pattern was noticed for the greige warp yarns for the left-hand weave.

The elongation in the warp yarns for the Sanforized samples, both right-hand and left-hand, showed an increase from the forty-gram through the sixty-gram samples and a decrease in the seventy-gram samples for both.

The filling yarns in the greige dropped elongation from the lowest tension to the highest tension for both right-hand and left-hand weaves, except for the seventy-gram left-hand sample, which increased.

The Sanforized filling samples showed no pattern for the elongation.

Table 6. Summary of Single Yarn Breaks
Breaks in Pounds

Grams Tension	Warp Greige	Warp Sanforized	Filling Greige	Filling Sanforized
		Right Hand		
40	1.489	1.218	1.104	1.111
50	1.436	1.196	1.104	1.146
60	1.421	1.238	1.093	1.313
70	1.381	1.234	1.075	1.238
		Left Hand		
40	1.486	1.191	1.128	1.195
50	1.469	1.215	1.117	1.126
60	1.473	1.299	1.106	1.231
70	1.391	1.272	1.133	1.278

The crimp in the greige samples showed a decrease from the lowest to the highest tensions for the warp yarns. The filling yarns showed the opposite effect, or an increase in crimp from the lowest to the highest tensions. The total crimp, warp plus filling decreased, as the tension increased.

The crimp in the Sanforized samples showed in the right-hand warp samples an increase up through the sixty-gram samples and then a decrease

Table 7. Summary of Single Yarn Elongation. Elongation in Percent

Grams Tension	Warp Greige	Warp Sanforized	Filling Greige	Filling Sanforized
		Right Hand		
40	7.94	7.95	7.80	9.03
50	6.63	7.70	6.92	9.91
60	6.48	8.28	7.20	10.37
70	6.03	7.56	6.80	9.37
		Left Hand		
40	6.96	7.97	7.59	10.09
50	6.82	7.95	6.98	9.18
60	6.99	8.34	6.78	10.77
70	6.99	7.94	7.19	9.52

in crimp for the seventy-gram samples. The left-hand warp samples showed an increase instead of an unexpected increase in the seventy-gram samples. The crimp in the filling for the right-hand samples showed an increase in crimp from the lowest to the highest tension. In the left-hand filling samples an increase occurred through the sixty-gram samples, then a decrease. The seventy-gram Sanforized samples showed opposite reactions both for the warp and for the filling between the right-hand and left-hand samples.

For both right-hand and left-hand weaves of the Sanforized samples the total crimp - warp crimp and filling crimp added together - increased from the forty-gram samples through the sixty-gram samples and decreased for the seventy-gram samples.

The ravelled strip break results were divided by the average number of ends or picks per inch for each sample to secure a comparison with the single yarn breaks. The right-hand greige warp showed an increase in

Table 8. Summary of Crimp Percent

Grams Tension	Greige Warp	Greige Filling	Sanforized Warp	Sanforized Filling
		Right Hand		
40	9.89	6.54	12.20	11.08
50	7.35	7.41	12.15	12.10
60	7.17	7.35	12.78	12.79
70	6.46	7.80	11.51	13.13
		Left Hand		
40	8.95	6.80	11.91	11.08
50	7.70	7.06	12.59	12.76
60	6.95	7.15	12.07	13.18
70	5.45	7.83	12.38	12.76

breaking strength up through the sixty-gram tension samples and decreased with the seventy-gram sample. The left-hand greige warp showed an increase of breaking strength from the forty-gram samples through the seventy-gram samples, with a marked increase for the seventy-gram sample.

The Sanforized warp samples showed an increase in breaking strength from the forty-gram samples through the seventy-gram samples.

The greige filling samples for the right-hand weave, generally, increased in breaking strength with tension. The left-hand samples showed no pattern. The Sanforized filling samples showed an increase in breaking strength from the forty-gram samples through the sixty-gram samples and a decrease in breaking strength for the seventy-gram samples. This same pattern followed for both the right-hand and left-hand weaves.

The elongation for the ravelled strip breaks in the greige showed, for the warp yarns, a decrease in elongation from the forty-gram tension samples through the seventy-gram tension samples for both the right-hand

and the left-hand weaves. In the greige filling yarns the elongation increased from the forty-gram samples through the seventy-gram samples.

The Sanforized warp samples, both right-hand and left-hand, showed, generally, an increase in elongation from the forty-gram through the seventy-gram tensions. The Sanforized filling samples also showed, generally, an increase of elongation from the forty-gram through the seventy-gram samples for both weaves.

Table 9. Summary of Ravelled Strip Breaks in Pounds Divided by Ends or Picks per Inch

Grams Tensions	Greige Warp	Greige Filling	Sanforized Warp	Sanforized Filling
		Right Hand		
40	1.413	1.406	1.230	1.260
50	1.578	1.388	1.280	1.300
60	1.592	1.478	1.391	1.373
70	1.531	1.471	1.449	1.370
		Left Hand		
40	1.430	1.420	1.270	1.085
50	1.480	1.450	1.345	1.360
60	1.503	1.360	1.430	1.368
70	1.572	1.430	1.431	1.357

The warp shrinkage for the greige samples increased with an increase in tension; however, the shrinkage for the left-hand weave showed a greater increase in shrinkage with an increase of tension. The filling shrinkage in the greige samples showed no change between the lowest and the highest tensions for the right-hand weave. A slight increase occurred for the left-hand weave in going from the lowest to the highest tensions.

Table 10. Summary of Elongation in Inches for Ravelled Strip Breaks

Grams Tensions	Greige Warp	Greige Filling	Sanforized Warp	Sanforized Filling
		Right Hand		
40	.592	.482	.629	.657
50	.532	.477	.634	.785
60	.506	.494	.712	.829
70	.505	.507	.726	.804
		Left Hand		
40	.607	.464	.638	.623
50	.532	.492	.647	.789
60	.519	.488	.748	.769
70	.498	.508	.738	.794

The Sanforized warp samples showed a negative residual shrinkage in the warp. The right-hand weave showed no appreciable change in the amount of shrinkage as the tension changed. The left-hand warp samples showed a decrease in negative residual shrinkage in going from the forty-gram samples to the seventy-gram samples. This decrease for the left-hand Sanforized samples indicates that there was less over-shrinkage for the higher tension samples than for the lower tension samples.

The Sanforized filling samples showed for the fifty, sixty, and seventy-gram samples little residual shrinkage for either weave. The forty-gram samples showed appreciable residual shrinkage for both the right-hand and the left-hand weaves.

Table 11. Summary of Greige Shrinkage and Sanforized Residual Shrinkage in Inches

Grams Tensions	Right-Hand Warp	Right-Hand Filling	Left-Hand Warp	Left-Hand Filling
		Greige		
40	1.53	0.89	1.50	0.94
50	1.69	0.99	1.50	0.97
60	1.64	0.93	1.82	0.99
70	1.76	0.89	1.92	1.04
		Sanforized		
40	-0.37	0.18	-0.53	0.19
50	-0.38	-0.01	-0.42	0.07
60	-0.39	-0.06	-0.37	-0.02
70	-0.35	0.04	-0.04	0.06

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The primary conclusion which can be reached from the results obtained in this investigation is that the control of warp tension is important. With the width varying seven tenths of an inch in Sanforized material, the difficulties encountered in maintaining the specified width in the process would be considerably lessened by the same tension maintained rigidly on all looms weaving a particular style of goods. The results showing the construction of the fabric, particularly the picks per inch, indicate that a saving can be made by maintaining proper control on the warp tension so that the picks per inch might fall closer to the minimum requirements without the danger of going under the minimum requirements with uncontrolled tension. A difference of over six percent in picks per inch was found between the lowest and the highest tensions in the Sanforized goods.

The following conclusions can be reached:

An increase in tension causes a decrease in width for both the greige and Sanforized states.

The bow is greatest at intermediate tensions.

The ends per inch and picks per inch increase with an increase in tension.

Air permeability decreases with an increase in tension.

Single yarn tests for the greige warp and filling show a decrease in breaking strength with an increase in tension.

Single yarn tests for the Sanforized warp and filling show an increase in breaking strength with an increase in tension.

Warp crimp in the greige decreases with an increase in tension.

Filling crimp in the greige increases with an increase in tension.

Warp crimp in the Sanforized state increases up to a point with an increase in tension, then decreases.

Filling crimp in the Sanforized state increases with an increase in tension.

Warp breaking strength for the greige state in ravelled strip tests increases with an increase in tension.

Warp shrinkage in the greige state increases with an increase in tension.

Filling shrinkage in the greige state is unaffected by a change in tension.

The fact that the bow was greatest at intermediate tensions is probably best explained by the lack of great tension on the selvages at the low tensions and their failing to impede the filling while it was being beaten-up into the cloth. At the higher tensions there probably was sufficient tension in the center of the cloth, as well as at the selvages to present a more uniform impediment to the filling in going into the cloth.

The primary observation of importance about construction is the decrease in ends per inch and increase in picks per inch of the seventy-gram sample over the sixty-gram sample in the left-hand weave. There is a possibility that the direction of twist in the yarns affects the construction of the cloth. There is also the possibility that the amount of this influence on the construction will vary among different weaves.

The thickness followed the overall construction, ends plus picks, as far as can be observed and presents no unexpected variations.

The air permeability of the fabric samples presents an interesting observation. Although the picks per inch increased markedly between the sixty and seventy-gram Sanforized samples of the left-hand weave, the air flow increased. This result was not seen in the right-hand samples, although, the thickness was virtually the same for the sixty and seventy-gram samples of both weaves. This suggests that possibly the air flow follows more closely the ends per inch than the picks per inch.

The results obtained by dividing the breaking strength in pounds of the greige warp ravelled strips by the number of ends per inch presents a very interesting observation. For the single yarns the breaking strength decreased with an increase in tension; whereas, for the ravelled strips the breaking strength increased with an increase in tension, except for the seventy-gram right-hand weave. This seems to indicate that the recovery experienced by the cloth upon being removed from the loom tends to bind the fibers together more for the high-tension samples than for the low-tension samples.

The greige warp crimp decreased with an increase in tension, indicating that the filling yarns were less able to cause the warp ends to bend over them with an increase in tension. The filling yarns were caused to bend around the warp yarns more with an increase in tension on the warp, as is indicated by the increase in filling crimp with an increase in warp tension.

The results obtained from the Sanforized warp samples indicated that the increase in tension caused an additional recovery in the warp yarns, resulting in an increase in warp crimp up through a certain point in the tensions, after which point this recovery was unable to compensate for the original searcity of crimp.

Expected results were obtained for the shrinkage in the greige warp samples, namely, an increase in shrinkage with an increase in tension. Apparently this weave was tight enough that the filling shrinkage varied little from one tension to another.

The amount of tension on the warp showed little effect on the amount of residual warp shrinkage for the Sanforized samples. Apparently the samples woven at the various tensions relaxed appreciably in the greige state after removal from the loom. As a result of this relaxation the amount of residual shrinkage was about the same in all samples. The forty-gram left-hand samples shrank to a greater extent than the other samples. There appears to be no forthright explanation.

Except in two cases, the filling shrank to a stable state by allowing the cloth to attain its own width on the compressive shrinkage machine. The forty-gram right-hand and left-hand Sanforized samples contained some residual shrinkage. This was probably due to the scarcity of crimp in the forty-gram greige samples, resulting in more possible crimping in subsequent processes.

The unexpected results occurring between the sixty and seventy-gram samples could be investigated further. The possibility of twist relative to the weave is one direction in which investigation could proceed.

Additional investigation could be warranted in determining the relative effects of ends per inch on air permeability.

APPENDIX

Table 12. Effects of Tension on Greige Widths

	40 grams	50 grams	60 grams	70 grams
		Inches		
Right Hand	38.01	37.67	37.68	37.55
	38.00	37.51	37.66	37.40
	38.05	37.75	37.70	37.48
	38.00	37.60	37.63	37.58
	38.04	37.66	37.78	37.48
	38.02	37.64	37.69	37.50
Left Hand	37.90	37.80	37.68	37.48
	37.70	37.80	37.71	37.55
	37.92	37.58	37.67	37.35
	37.78	37.52	37.70	37.40
	37.98	37.78	37.52	37.38
	37.86	37.69	37.67	37.43

Table 13. Effects of Tension on Sanforized Widths

	40 grams	50 grams	60 grams	70 grams
		Inches		
Right Hand	34.69	34.52	34.29	34.19
	34.75	34.50	34.26	34.25
	35.00	34.62	34.20	34.12
	35.00	34.38	34.10	34.19
	34.88	34.39	34.30	34.12
	34.86	34.48	34.23	34.17
Left Hand	34.81	34.50	34.30	34.20
	34.88	34.40	34.26	34.40
	34.94	34.38	34.25	34.20
	34.92	34.47	34.20	34.25
	34.62	34.45	34.25	34.10
	34.84	34.44	34.25	34.23

Table 14. Effects of Tension on Greige Bow

	40 gram	50 gram	60 gram	70 gram
		Inches		
Right Hand	.31"	.41"	.55"	.34"
	.29"	.44"	.52"	.40"
	.39"	.47"	.46"	.43"
	.35"	.41"	.50"	.43"
	.335"	.432"	.508"	.400"
Left Hand	.40"	.43"	.41"	.29"
	.38"	.38"	.37"	.28"
	.28"	.43"	.41"	.24"
	.40"	.43"	.42"	.24"
	.365"	.417"	.402"	.262"

Table 15. Effects of Tension on Greige Construction

Right Hand Warp	Right Hand Filling		Left Hand Warp	Left Hand Filling
		40 grams		
70.0	56.0		75.0	56.0
73.5	58.0		75.0	59.4
73.0	58.0		74.0	57.8
74.5	59.0		75.0	53.5
74.0	55.5		75.0	59.5
74.5	56.6		75.0	59.8
74.6	56.0		75.0	56.0
74.0	58.3		75.0	55.5
74.5	56.6		75.0	55.5
74.0	57.9		75.0	59.0
73.66	57.19		74.90	57.20
		50 grams		
74.0	60.0		75.0	58.0
75.0	61.0		75.2	57.0
74.5	62.0		75.0	59.0
74.0	61.0		76.0	60.1
75.0	59.5		74.6	60.0
74.9	59.6		75.6	57.2
75.2	59.6		75.0	56.6
75.2	60.2		75.4	59.0
75.0	60.0		73.0	61.0
75.0	61.0		75.0	60.0
74.78	60.39		74.98	58.79

Table 15. Effects of Tension on Greige Construction (Continued)

Right Hand Warp	Right Hand Filling	Left Hand Warp	Left Hand Filling
	60 gram		
74.2	61.0	74.5	60.0
75.0	60.0	76.0	60.0
74.6	60.3	76.0	60.5
74.0	61.0	76.0	59.5
75.0	61.8	76.2	59.3
76.0	59.0	76.0	60.4
75.6	59.5	74.8	59.0
75.4	60.8	75.0	58.5
75.0	60.3	75.0	60.0
75.0	61.0	75.4	60.3
74.98	60.47	75.49	59.75
	70 gram		
76.0	58.0	75.0	59.5
75.0	59.5	75.0	60.0
75.0	60.0	75.5	60.5
76.2	60.0	75.5	59.0
75.3	59.8	75.4	61.2
75.7	60.6	75.6	61.6
76.0	62.0	75.1	62.5
75.0	60.8	75.1	60.5
76.0	60.0	76.0	60.2
76.0	59.0	75.9	61.3
75.62	59.97	75.41	60.63

Table 16. Effects of Tension on Sanforized Construction

Right Hand Warp	Right Hand Filling		Left Hand Warp	Left Hand Filling
		40 grams		
81.0	64.0		82.0	62.0
79.0	64.0		80.7	63.5
81.0	62.0		82.0	62.5
80.0	62.5		81.0	61.0
81.0	62.0		81.0	63.1
80.5	62.8		81.8	61.6
81.0	61.3		81.2	63.8
80.0	64.1		81.8	63.0
81.0	62.0		82.0	63.0
81.4	63.8		82.0	60.8
80.59	62.85		81.55	62.73
		50 grams		
81.5	63.5		82.5	62.5
81.0	63.5		82.5	65.0
82.2	65.0		82.0	66.5
81.8	65.5		82.5	65.0
81.5	64.8		82.0	62.8
80.5	63.0		83.0	64.5
81.3	62.5		82.0	64.0
82.1	62.5		82.0	62.0
82.2	63.8		82.0	61.8
81.5	63.9		82.0	64.0
81.56	63.80		82.25	63.81
		60 grams		
82.0	66.5		82.5	63.5
81.8	64.5		83.0	64.0
81.8	63.4		82.3	66.3
82.0	65.0		82.3	65.0
82.0	64.5		81.6	65.0
82.0	64.0		82.6	64.6
82.0	64.0		83.0	65.2
83.0	64.8		83.0	64.2
82.5	65.6		82.4	65.8
82.8	64.0		82.0	63.8
82.19	64.60		82.47	64.74

(Continued)

Table 16. Effects of Tension on Sanforized Construction (Continued)

Right Hand Warp	Right Hand Filling	Left Hand Warp	Left Hand Filling
	70 grams		
83.0	66.5	82.0	67.0
83.0	64.8	82.8	67.0
82.4	64.5	81.0	66.5
83.0	65.0	81.5	66.5
82.9	65.0	81.9	66.2
82.0	65.0	82.4	67.0
82.4	66.6	82.0	66.8
82.1	66.2	82.6	65.3
82.8	66.0	82.2	66.0
82.0	66.5	82.5	67.3
82.56	65.61	82.09	66.56

Table 17. Effects of Tension on Thickness in Greige

40 gram Right Hand	40 gram Left Hand	50 gram Right Hand	50 gram Left Hand
	.001 inch		
22.5	22.0	19.8	19.0
22.2	19.4	18.6	19.8
21.8	19.9	19.3	20.0
22.6	20.8	18.3	20.9
20.8	20.9	18.0	21.3
21.4	21.9	18.9	19.0
21.0	21.0	19.7	19.9
21.4	21.8	19.8	19.4
22.2	20.9	21.1	20.2
22.0	21.1	20.3	21.2
21.79	20.96	19.38	20.07

(Continued)

Table 17. Effects of Tension on Thickness in Greige (Continued)

60 grams		70 grams	
Right Hand	Left Hand	Right Hand	Left Hand
.001 Inch			
18.2	18.8	18.2	18.5
18.7	18.8	18.1	18.2
18.8	19.7	16.8	18.8
19.6	18.8	18.2	18.0
18.3	18.9	18.8	17.6
20.5	19.0	17.2	18.4
18.0	18.7	18.0	18.0
19.2	19.4	18.6	18.2
19.0	19.9	18.5	19.1
19.7	18.5	18.8	18.2
19.00	19.05	18.12	18.30

Table 18. Effects of Tension on Sanforized Thickness

40 grams		50 grams	
Right Hand	Left Hand	Right Hand	Left Hand
.001 Inch			
18.5	17.2	17.5	17.8
17.3	17.1	17.2	16.5
17.8	17.2	17.1	17.2
17.2	17.0	17.4	16.7
16.7	16.9	18.0	17.0
17.4	17.0	17.8	17.2
17.2	17.5	17.7	16.8
17.5	16.8	16.7	17.1
17.8	17.6	16.8	17.4
17.3	17.5	17.5	17.2
17.47	17.18	17.37	17.09

(Continued)

Table 18. Effects of Tension on Sanforized Thickness (Continued)

60 grams Right Hand	Left Hand	70 grams Right Hand	Left Hand
	.001 Inch		
17.1	17.5	17.8	17.8
17.3	16.8	17.4	18.2
17.5	17.5	17.8	17.3
18.1	17.5	17.5	16.7
16.8	16.7	17.2	17.1
17.3	17.5	17.1	16.8
18.2	17.3	17.5	16.8
17.1	17.0	17.5	17.8
17.7	17.8	17.3	17.0
17.3	17.3	17.3	17.2
17.44	17.29	17.44	17.27

Table 19. Effects of Tensions on Greige Air Permeability

40 grams Right Hand	Left Hand	50 grams Right Hand	Left Hand
	Cubic ft. per sq. ft. of fabric		
92.9	85.8	65.2	62.8
87.3	79.4	72.7	69.9
82.2	76.2	68.9	57.0
82.1	95.7	59.8	62.8
87.2	88.7	54.9	74.2
89.4	87.2	65.2	62.3
82.2	79.9	59.3	62.8
85.8	76.7	61.3	74.2
89.3	82.2	64.7	64.2
83.6	72.5	57.8	60.3
86.20	82.43	62.98	65.05

(Continued)

Table 19. Effects of Tensions on Greige Air Permeability (Continued)

60 grams Right Hand	60 grams Left Hand	70 grams Right Hand	70 grams Left Hand
Cubic ft. per sq. ft. of fabric			
57.6	54.9	57.1	59.3
61.9	62.3	60.3	60.3
65.2	69.9	58.7	62.3
56.5	69.9	62.5	57.8
64.2	67.4	63.6	57.0
64.2	62.8	54.4	60.3
61.3	67.5	57.6	62.8
58.1	69.4	59.2	62.3
60.8	62.3	59.3	61.8
59.2	57.3	53.9	58.3
60.90	64.37	58.66	60.22

Table 20. Effects of Tension on Sanforized Air Permeability

Right Hand	Left Hand	Right Hand	Left Hand
40 grams		50 grams	
Cubic ft. per sq. ft. of fabric			
12.2	13.3	13.4	12.4
13.2	13.3	12.7	13.6
12.7	11.5	12.5	12.5
12.9	11.7	11.1	12.2
13.6	14.6	12.2	12.5
13.8	13.6	11.1	12.9
13.2	13.2	12.8	12.6
13.3	14.4	14.4	12.0
13.7	14.1	13.8	11.9
14.2	13.8	12.8	13.1
13.28	13.35	12.68	12.57
60 Grams		70 Grams	
12.4	11.7	10.7	11.7
12.2	11.1	10.9	10.9
11.9	11.3	11.1	10.5
11.8	10.9	10.6	11.9
12.2	10.9	11.4	11.0
11.8	11.4	11.7	11.4
12.5	12.0	11.8	10.9
12.0	12.8	12.1	11.8
12.6	10.6	10.6	12.1
11.8	11.3	11.2	12.4
12.12	11.40	11.21	11.46

Table 21. Effects of Tension on Greige Single Yarn Breaking Strength and Elongation

Right Hand Warp		Filling		Left Hand Warp		Filling	
Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)
40 grams							
1.40	6.5	1.11	7.8	1.36	5.5	1.02	6.5
1.36	7.0	1.11	8.9	1.82	7.0	1.09	7.8
1.50	7.2	1.02	7.5	1.55	7.0	1.12	7.0
1.80	8.0	1.10	8.4	1.60	8.0	1.30	8.8
1.35	8.0	.95	7.0	1.40	6.8	.86	5.8
1.60	10.2	1.00	7.5	1.50	5.6	.85	6.2
1.52	8.0	.90	6.9	1.52	7.8	1.10	8.0
1.50	9.8	.85	6.8	1.31	6.3	1.11	8.8
1.54	9.1	1.15	9.0	1.30	6.8	1.55	8.5
1.50	7.0	1.15	8.8	1.40	6.8	1.30	8.0
1.76	10.0	1.10	7.4	1.88	9.1	1.00	8.0
1.35	6.0	1.15	7.8	1.45	8.3	1.30	8.0
1.51	8.6	1.40	9.0	1.33	6.8	1.30	8.0
1.60	9.0	1.29	8.5	1.62	6.3	.85	7.0
1.40	8.2	1.10	8.0	1.58	7.3	.88	7.2
1.45	6.1	.98	6.5	1.81	7.3	.90	6.0
1.43	7.2	1.40	8.2	1.45	7.3	1.40	8.1
1.50	8.0	1.20	7.2	1.33	7.0	1.22	8.2
1.50	8.0	1.00	6.4	1.25	6.0	1.21	8.0
1.22	7.0	1.13	8.5	1.26	6.2	1.20	8.0
1.489	7.94	1.104	7.80	1.486	6.96	1.128	7.59
50 grams							
1.20	7.0	1.21	7.2	1.35	6.2	1.02	7.8
1.60	7.0	1.20	7.0	1.74	7.0	1.05	8.0
1.66	8.0	1.00	6.5	1.40	7.0	1.30	7.2
1.50	6.0	1.01	6.8	1.44	6.5	.95	7.0
1.50	11.0	1.35	8.0	1.57	7.0	1.05	7.0

Table 21. Effects of Tension on Greige Single Yarn Breaking Strength and Elongation (Continued)

Right Hand Warp		Filling		Left Hand Warp		Filling	
Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)
			50 grams				
1.40	6.0	1.16	6.4	1.45	5.8	1.00	6.8
1.46	7.0	1.02	7.5	1.55	6.2	1.10	7.1
1.40	7.0	1.06	7.0	1.40	6.2	1.20	7.2
1.30	6.0	1.10	7.0	1.40	7.0	1.20	7.2
1.25	6.5	1.10	7.1	1.72	7.0	1.00	5.2
1.50	7.2	1.14	7.0	1.50	6.0	1.20	7.2
1.20	5.5	1.25	6.9	1.03	6.0	1.14	7.4
1.30	5.5	1.22	7.2	1.50	7.3	1.10	6.8
1.60	6.0	1.35	7.5	1.60	8.0	1.35	8.0
1.16	4.5	.95	6.8	1.48	7.0	1.26	8.0
1.54	6.0	1.02	6.1	1.70	9.0	1.20	6.2
1.55	6.0	1.11	7.1	1.20	6.0	1.10	6.8
1.65	7.2	1.00	6.5	1.72	8.0	1.12	6.0
1.25	5.2	.82	6.0	1.60	7.1	1.10	6.6
1.70	8.0	1.01	6.9	1.04	6.2	.90	6.0
1.436	6.63	1.104	6.92	1.469	6.82	1.117	6.98
			60 grams				
1.35	5.2	1.10	8.0	1.30	6.2	1.26	6.8
1.68	6.2	1.06	7.8	1.40	6.8	1.00	6.2
1.62	7.0	1.20	7.0	1.50	6.0	1.10	8.1
1.42	6.5	1.12	6.8	1.75	7.2	1.01	6.8
1.28	6.8	1.06	6.2	1.80	8.0	1.00	6.1
1.30	6.2	1.06	7.0	1.60	6.3	1.12	6.8
1.70	7.0	1.20	8.0	1.30	6.4	1.16	7.2
1.46	7.0	1.11	7.8	1.48	7.8	1.14	7.3
1.40	7.0	.95	7.0	1.72	7.8	1.11	7.8

(Continued)

Table 21. Effects of Tension on Greige Single Yarn Breaking Strength and Elongation (Continued)

Right Hand Warp		Filling		Left Hand Warp		Filling	
Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)
				60 grams			
1.43	7.8	.92	6.2	1.32	6.8	1.00	7.0
1.23	5.2	1.02	8.5	1.65	7.7	.88	6.2
1.10	5.8	.90	6.3	1.38	6.2	1.02	6.5
1.60	7.0	1.25	7.0	1.66	7.4	.90	5.8
1.32	6.0	1.11	6.8	1.30	7.0	1.10	7.0
1.57	6.8	1.11	7.2	1.21	6.2	.85	7.0
1.52	6.4	.91	6.0	1.66	7.8	.88	6.2
1.40	6.8	1.26	7.8	1.62	7.0	.82	5.8
1.35	7.0	1.15	7.8	1.30	8.0	.88	6.2
1.32	6.8	1.25	7.6	1.40	7.0	1.00	7.8
1.36	5.0	1.12	7.3	1.11	6.2	1.10	7.0
1.421	6.48	1.093	7.20	1.473	6.99	1.016	6.78
				70 grams			
1.50	7.0	1.16	6.8	1.30	6.0	.90	6.8
1.46	5.2	1.15	7.2	1.20	5.2	.96	6.0
1.02	4.8	.80	5.2	1.37	6.4	1.25	7.5
1.22	5.2	.82	4.8	1.45	8.0	1.30	7.8
1.68	5.3	1.00	7.8	1.20	6.7	1.11	7.4
1.61	6.2	1.10	7.2	1.30	6.2	1.32	8.0
1.32	5.2	1.35	7.8	1.35	8.4	.85	5.8
1.38	8.0	1.30	7.6	1.20	5.0	.76	6.1
1.20	5.2	.98	8.0	1.33	6.8	1.08	7.5
1.38	5.2	.96	6.2	1.60	8.0	1.00	6.0
1.20	5.0	1.16	7.2	1.80	7.8	1.00	6.8
1.90	8.0	1.02	6.0	1.40	8.0	.91	7.0
1.10	6.0	1.06	7.0	1.55	6.8	1.42	9.0
1.50	8.0	1.14	7.4	1.55	7.5	1.06	7.0
1.30	6.0	1.17	6.8	1.11	5.8	1.21	7.8
1.65	7.0	1.20	7.0	1.25	6.5	1.40	9.0

(Continued)

Table 21. Effects of Tension on Greige Single Yarn Breaking Strength and Elongation (Continued)

Right Hand Warp		Filling		Left Hand Warp		Filling	
Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)
70 grams							
1.30	6.8	.85	5.8	1.51	6.8	1.33	7.3
1.22	5.2	1.03	7.0	1.60	9.0	1.30	7.0
1.32	5.4	1.15	7.0	1.30	7.0	1.10	6.0
1.36	6.0	1.11	6.2	1.45	8.0	1.40	8.0
1.381	6.03	1.075	6.80	1.391	6.99	1.133	7.19

Table 22. Effects of Tension on Sanforized Single Yarn Breaking Strength and Elongation

Right Hand Warp		Filling		Left Hand Warp		Filling	
Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)
40 grams							
1.00	8.0	1.01	8.8	1.10	7.0	1.15	9.8
1.25	8.4	.95	8.8	1.25	8.0	1.18	9.0
.95	9.5	1.06	9.0	1.40	8.0	1.20	9.5
1.10	7.0	1.30	10.5	.95	6.0	1.25	10.0
1.21	7.3	1.10	8.0	1.30	8.0	1.30	10.0
1.56	9.0	1.04	8.0	1.40	8.2	1.45	9.5
1.25	7.0	1.25	9.0	1.12	8.5	1.05	9.2
1.40	7.2	1.20	10.0	.65	8.0	1.32	11.5
1.50	8.0	1.12	9.5	.80	7.0	1.12	10.2
1.02	8.2	.85	6.8	1.15	9.5	1.10	11.8
1.21	7.2	1.02	10.5	1.35	8.0	1.22	11.0
.82	7.8	1.16	9.0	1.58	9.8	1.38	10.5
1.32	8.0	1.30	9.0	1.12	7.5	1.48	11.5

(Continued)

Table 22. Effects of Tension on Sanforized Single Yarn Breaking Strength and Elongation (Continued)

Right Hand Warp		Filling		Left Hand Warp		Filling	
Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)
			40 grams				
1.54	8.6	1.40	9.0	1.30	9.0	1.26	11.0
1.16	7.0	.95	8.2	1.23	8.1	1.12	9.5
1.50	8.0	.90	8.0	1.30	9.0	1.08	9.8
1.16	8.6	1.15	9.0	1.31	8.8	.80	10.9
1.33	8.4	1.11	9.0	1.12	7.0	1.20	10.2
.98	8.0	1.20	10.0	1.17	7.0	1.22	9.5
1.10	7.8	1.15	10.5	1.21	7.0	1.02	8.2
1.218	7.95	1.111	9.03	1.191	7.97	1.195	10.09
			50 grams				
1.22	7.1	1.12	12.0	1.21	7.0	1.22	9.8
1.00	7.3	1.30	11.0	1.16	6.5	1.06	10.0
1.22	7.6	1.08	9.0	1.10	7.2	1.50	11.0
.94	7.3	1.28	9.4	1.48	9.0	1.48	11.5
1.50	9.4	1.20	10.0	1.06	9.0	1.02	8.0
1.10	8.0	1.05	9.0	1.20	7.8	1.18	9.3
1.50	8.0	1.16	9.8	1.30	6.0	1.08	10.0
1.14	7.4	1.04	8.5	1.41	8.0	1.06	10.0
1.11	7.8	1.23	9.8	1.21	7.0	1.06	9.5
1.28	7.8	1.06	10.0	1.30	9.0	1.20	9.5
.98	6.0	1.12	11.0	1.20	8.0	.92	7.5
1.32	8.0	1.12	10.0	1.04	7.2	.98	9.0
1.32	7.8	1.04	9.8	1.32	7.8	1.02	9.5
1.27	8.0	1.21	10.5	1.02	8.2	1.18	11.2
1.31	8.2	.88	9.0	1.21	9.8	1.34	9.5
1.32	8.4	.80	10.2	1.30	10.6	1.06	8.5
.99	6.9	1.45	10.2	1.12	10.0	1.08	8.3
1.32	7.3	1.20	9.8	.80	6.0	1.04	7.3

(Continued)

Table 22. Effects of Tension on Sanforized Single Yarn Breaking Strength and Elongation (Continued)

Right Hand Warp		Filling		Left Hand Warp		Filling	
Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)
50 grams							
1.08	7.8	1.48	10.0	1.35	8.0	.96	6.3
1.00	8.0	1.10	9.2	1.52	7.0	1.08	8.0
1.196	7.70	1.146	9.91	1.215	7.95	1.126	9.18
60 grams							
1.48	9.0	1.50	11.3	1.08	7.2	1.18	10.0
1.37	8.8	1.35	11.8	1.38	8.0	1.20	10.0
1.20	8.3	1.10	8.0	1.10	7.0	1.44	12.0
1.40	8.0	1.40	9.0	1.25	8.0	1.20	9.5
1.42	8.5	1.36	11.2	1.14	7.3	1.23	10.5
1.32	7.4	1.36	12.0	1.31	8.7	1.38	12.0
1.28	7.0	1.10	11.3	1.60	8.3	1.15	10.6
1.08	7.8	1.18	10.3	1.32	8.8	1.08	11.6
1.12	8.0	1.14	10.0	1.48	10.0	1.23	10.0
1.18	9.8	1.55	12.2	1.54	9.0	1.30	10.2
1.06	8.8	1.26	9.3	1.50	9.2	1.20	10.0
1.30	8.0	1.30	12.0	.98	8.0	1.04	9.5
1.14	7.0	1.45	9.4	1.25	9.8	1.30	11.0
1.33	9.4	1.46	11.0	1.50	10.0	1.20	12.0
1.12	10.0	1.23	9.0	1.30	7.0	1.30	12.0
1.00	7.6	1.50	10.0	1.51	9.0	1.25	11.0
1.23	8.8	1.25	10.3	1.50	8.0	1.30	11.5
1.12	7.6	1.22	10.0	1.16	8.0	1.21	10.5
1.40	8.0	1.40	9.5	1.10	8.5	1.21	11.0
1.21	8.1	1.15	9.8	.98	7.0	1.22	10.5
1.238	8.28	1.313	10.37	1.299	8.34	1.231	10.77

(Continued)

Table 22. Effects of Tension on Sanforized Single Yarn Breaking Strength and Elongation (Continued)

Right Hand Warp		Filling		Left Hand Warp		Filling	
Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)	Break(lbs)	Elongation(%)
			70 grams				
1.35	8.0	1.30	10.0	1.38	7.3	1.22	9.3
1.50	11.0	1.12	8.0	1.20	7.3	1.48	9.7
1.51	13.0	1.31	9.0	1.22	6.5	1.00	8.8
1.15	8.0	1.31	8.0	1.30	8.0	1.35	9.2
.92	5.0	1.21	7.8	1.40	7.0	1.34	10.0
1.30	8.0	1.25	10.5	1.30	7.8	1.51	11.4
1.10	7.0	1.20	9.0	1.26	7.5	1.38	8.8
1.12	7.0	1.14	9.0	1.08	7.3	1.23	10.4
1.15	7.0	1.20	9.5	1.34	9.0	1.64	11.0
1.10	6.0	1.40	8.5	1.22	7.9	1.46	9.8
1.36	7.0	1.10	9.0	1.12	7.9	1.47	9.8
1.11	7.0	1.05	9.5	1.22	8.2	1.64	10.0
1.40	8.0	1.22	10.0	1.30	7.3	1.88	11.0
1.21	8.0	1.20	8.5	1.22	9.0	1.23	9.7
1.08	5.5	1.28	9.0	1.35	9.5	.86	9.0
1.12	6.8	1.45	10.0	1.51	8.0	.70	7.3
1.40	8.5	1.45	12.3	1.55	8.6	1.03	9.0
1.25	6.7	1.32	13.2	1.11	8.5	.88	8.0
1.20	6.8	1.01	7.6	1.04	7.9	1.12	9.0
1.35	7.0	1.25	9.0	1.32	8.4	1.15	9.3
1.234	7.56	1.238	9.37	1.272	7.94	1.278	9.52

Table 23. Effects of Tension on Greige Crimp and Take-up

Right Hand Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)	Left Hand Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)
	40 Gram Warp				40 Gram Filling		
10.4	9.2	10.4	9.4	7.2	6.6	6.6	6.2
10.0	9.1	9.8	9.0	5.8	5.2	6.0	5.6
9.8	9.0	9.8	9.2	6.2	5.8	6.4	6.0
9.8	9.0	9.8	9.0	5.8	5.6	7.2	6.6
10.8	9.8	9.6	8.8	5.6	5.2	7.2	6.8
9.8	8.8	10.0	9.2	6.4	6.2	7.0	6.6
10.0	9.0	7.2	6.8	6.4	6.2	7.4	7.0
9.6	8.8	7.8	7.2	6.8	6.4	6.8	6.4
10.0	9.0	8.0	7.4	6.6	6.2	7.0	6.6
9.4	8.2	7.8	7.2	6.8	6.4	6.8	6.4
9.8	8.8	7.2	6.6	6.6	6.2	6.6	6.2
8.8	8.0	7.8	7.2	6.2	6.2	7.2	6.8
9.4	8.2	9.6	8.8	7.2	6.8	7.2	6.6
9.8	9.0	8.0	7.4	6.2	6.0	7.2	6.6
9.8	9.0	8.0	7.4	6.8	6.4	6.8	6.2
10.6	9.6	9.8	9.0	6.2	5.8	7.4	7.0
10.2	9.2	9.0	9.0	6.8	6.4	6.0	5.6
9.8	9.2	10.0	9.0	6.2	5.8	6.0	5.6
10.0	9.0	9.6	8.8	7.8	7.2	7.0	6.4
10.0	9.0	9.8	9.0	7.2	6.6	6.2	5.8
9.89	8.94	8.95	8.27	6.54	6.16	6.80	6.35
	50 Gram Warp				50 Gram Filling		
8.0	7.0	8.0	7.4	8.0	7.4	6.8	6.4
9.0	8.4	7.6	7.2	6.8	6.4	7.4	7.0
7.6	7.2	8.4	7.8	7.8	7.2	7.2	6.6
8.8	8.2	7.6	7.2	7.8	7.2	6.4	6.2
5.8	5.6	8.2	7.6	7.2	6.6	7.2	6.6
6.8	6.4	8.8	8.0	7.9	7.3	7.8	7.2

(Continued)

Table 23. Effects of Tension on Greige Crimp and Take-up (Continued)

Right Hand Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)	Left Hand Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)
	50 Gram Warp				50 Gram Filling		
6.0	5.8	7.4	6.8	7.6	7.2	6.8	6.4
7.0	6.6	8.0	7.4	7.0	6.6	7.0	6.6
9.4	8.8	7.8	7.2	6.8	6.8	6.6	6.2
8.8	8.0	7.2	6.7	7.0	6.6	7.0	6.6
7.2	6.6	8.2	7.6	7.0	6.6	7.4	6.8
6.8	6.4	7.8	7.4	6.8	6.4	8.2	7.2
7.8	7.2	7.2	6.8	7.6	7.0	7.2	6.8
7.0	6.6	7.4	6.8	8.2	7.2	7.2	6.8
6.0	5.6	7.2	6.8	7.0	6.6	6.4	6.0
6.2	5.8	7.8	7.3	7.6	7.2	7.6	7.0
7.2	6.6	8.0	7.4	7.8	7.2	6.8	6.4
7.2	6.6	7.4	7.2	7.6	7.2	6.6	6.2
6.8	6.4	7.2	6.8	7.2	6.8	6.4	6.0
7.6	6.8	6.8	6.4	7.6	7.2	7.2	6.8
7.35	6.83	7.70	7.19	7.41	6.93	7.06	6.59
	60 Gram Warp				60 Gram Filling		
7.2	6.6	6.2	5.8	7.2	6.8	7.4	6.8
7.0	6.6	6.4	6.2	7.2	6.2	8.4	8.0
7.4	7.0	8.2	7.6	7.4	7.2	6.8	6.4
6.4	6.0	7.2	6.6	6.8	6.4	6.6	6.2
7.0	6.8	6.6	6.2	6.8	6.4	7.4	7.0
6.8	6.6	6.6	6.2	6.4	6.0	7.4	6.8
8.0	7.0	8.2	7.6	6.8	6.4	6.8	6.4
7.8	7.2	6.8	6.4	6.6	6.2	7.0	6.6
6.4	6.0	7.8	7.2	7.6	7.2	8.2	7.6
6.8	6.4	6.8	6.4	8.0	7.4	7.0	6.6
7.2	6.2	6.4	6.2	7.2	6.6	6.6	6.2
7.0	6.2	5.8	5.6	8.0	7.4	6.8	6.4
7.6	7.2	7.2	6.8	7.2	6.8	7.2	6.8

(Continued)

Table 23. Effects of Tension on Greige Crimp and Take-up (Continued)

Right Hand Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)	Left Hand Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)
	60 Gram Warp				60 Gram Filling		
7.6	7.2	6.6	6.2	7.6	7.2	7.4	7.0
7.8	7.4	6.6	6.2	7.4	6.8	7.0	6.6
7.4	7.0	6.8	6.4	7.8	7.2	7.2	6.8
7.8	7.2	6.2	5.8	7.6	7.2	7.0	6.6
7.2	6.8	7.0	6.6	7.8	7.2	6.8	6.2
6.8	6.4	7.8	7.2	7.8	7.2	7.2	6.8
6.2	5.8	7.8	6.4	7.8	7.2	6.8	6.2
7.17	6.68	6.95	6.47	7.35	6.85	7.15	6.70
	70 Gram Warp				70 Gram Filling		
6.0	5.6	5.8	5.4	7.4	6.8	7.8	7.2
7.0	6.6	4.6	4.4	8.0	7.4	8.4	7.8
6.4	6.0	5.6	5.4	8.2	7.6	6.2	5.8
5.8	5.4	5.6	5.2	7.4	7.2	6.8	6.4
7.0	6.5	6.0	5.6	7.8	7.2	8.2	7.0
7.2	6.6	6.2	5.8	7.8	7.2	8.4	7.8
5.4	5.2	5.4	5.2	8.4	7.8	7.2	6.8
6.6	6.2	4.4	4.2	7.6	7.2	7.4	7.0
6.4	6.2	4.6	4.5	7.4	7.2	8.4	7.8
7.2	6.6	5.4	5.2	7.4	7.2	8.0	7.4
6.2	5.8	6.0	5.6	7.4	6.8	8.8	8.0
6.0	5.6	5.8	5.6	7.4	6.8	7.6	7.2
5.8	5.4	6.2	6.2	7.4	7.2	7.2	6.8
6.4	6.2	6.0	6.0	8.6	7.8	7.4	7.0
7.0	6.4	5.0	4.8	7.8	7.4	7.4	6.8
6.8	6.4	4.9	4.8	8.2	7.2	7.4	7.0
6.8	6.6	4.6	4.4	7.6	7.2	8.8	8.2
6.2	5.8	5.4	5.2	8.6	7.8	7.8	7.2
6.6	6.2	6.2	5.8	8.2	7.6	9.0	8.2
6.4	6.2	5.4	5.0	7.4	7.2	8.4	7.8
6.46	6.07	5.45	5.21	7.80	7.29	7.83	7.26

Table 24. Effects of Tension on Sanforized Crimp and Take-up

Right Hand		Left Hand		Right Hand		Left Hand	
Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)
40 Gram Warp				40 Gram Filling			
11.4	10.2	10.6	9.7	10.8	9.8	11.8	10.6
12.6	11.2	12.4	11.1	10.6	9.5	10.8	9.8
12.8	11.3	12.2	11.0	10.4	9.5	10.8	9.8
12.8	11.5	10.8	9.8	10.8	9.8	10.7	9.7
12.6	11.2	12.8	11.4	12.0	11.6	10.8	9.7
12.2	11.0	11.0	10.0	10.2	9.3	11.8	10.6
11.8	10.6	12.2	11.0	11.2	10.2	10.6	9.6
11.8	10.6	11.1	10.0	11.0	10.1	10.0	9.6
12.2	11.0	12.4	11.0	10.1	9.2	9.2	8.4
10.6	9.6	10.8	9.6	10.6	9.6	11.0	10.1
12.2	11.0	13.2	11.8	12.3	11.0	10.6	9.6
12.0	10.8	13.0	11.6	11.6	10.4	10.6	9.6
12.8	11.4	12.6	11.2	11.4	10.2	10.6	9.6
11.8	10.6	10.8	9.8	10.8	9.8	12.2	10.8
11.6	10.4	12.4	11.0	11.4	10.2	12.2	10.8
12.8	11.4	12.6	11.2	10.8	9.8	11.0	10.2
12.6	11.2	11.2	10.2	13.0	11.6	11.8	10.6
12.2	11.0	12.6	11.2	10.6	9.6	11.8	10.6
13.0	11.4	11.6	10.4	10.8	9.8	10.8	9.8
12.2	10.8	12.0	10.8	10.2	9.2	12.4	11.0
12.20	10.91	11.91	10.69	11.08	10.01	11.08	10.00
50 Gram Warp				50 Gram Filling			
12.6	11.2	13.2	11.8	13.2	11.7	13.2	11.6
10.8	9.8	12.6	11.2	11.0	9.8	12.8	11.2
12.6	11.3	11.6	10.4	12.2	10.9	13.8	12.0
13.0	11.3	11.6	10.4	10.6	9.6	12.8	11.4
11.0	10.0	11.4	10.2	12.0	10.8	12.4	11.2
13.4	11.8	13.4	11.8	10.7	9.7	12.2	10.8

(Continued)

Table 24. Effects of Tension on Sanforized Crimp and Take-up (Continued)

Right Hand		Left Hand		Right Hand		Left Hand	
Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)
50 Gram Warp				50 Gram Filling			
11.8	10.6	12.6	11.2	12.8	11.4	13.0	11.5
12.0	10.8	12.4	11.0	13.0	11.6	13.6	12.2
12.0	10.7	13.0	11.4	11.4	10.3	13.4	11.8
12.6	11.2	13.2	11.6	12.6	11.3	12.0	10.6
12.0	10.8	12.4	11.2	12.4	11.0	12.6	11.2
11.8	10.6	13.0	11.4	12.6	11.2	12.6	11.2
12.8	11.4	11.4	10.2	11.0	10.0	13.2	11.6
11.4	10.2	12.2	11.2	12.5	11.2	12.4	11.0
12.4	11.2	12.6	11.2	12.8	11.4	12.4	11.0
11.2	10.2	12.2	11.6	12.2	11.0	11.6	10.4
12.0	10.8	13.0	11.6	12.4	11.0	13.6	12.0
12.5	11.5	12.6	11.2	11.9	10.7	12.4	11.2
13.2	11.6	12.8	11.4	12.6	11.2	12.8	11.4
11.8	10.6	13.6	12.0	12.2	10.9	12.4	11.0
12.15	10.90	12.59	11.20	12.10	10.83	12.76	11.31
60 Gram Warp				60 Gram Filling			
14.8	13.0	12.6	11.2	13.4	11.6	12.4	11.0
12.4	11.1	12.6	11.2	13.4	11.7	12.2	10.8
13.0	11.6	13.0	11.5	12.6	11.2	12.6	11.2
13.0	11.6	13.0	11.4	11.0	10.0	12.6	11.2
12.8	11.4	12.2	10.8	12.6	11.2	12.8	11.2
12.6	11.2	11.6	10.4	13.8	12.2	12.8	11.4
12.6	11.2	11.6	10.4	12.6	11.2	13.8	12.0
12.6	11.2	12.4	11.0	12.8	11.4	14.0	12.2
11.0	9.9	11.6	10.4	12.8	11.4	13.4	11.8
11.8	10.6	12.8	11.4	12.2	11.0	13.6	12.1
13.6	12.0	12.4	11.0	13.6	12.0	13.6	12.0
12.5	11.1	12.4	11.0	13.6	12.0	13.6	12.0

(Continued)

Table 24. Effects of Tension on Sanforized Crimp and Take-up (Continued)

Right Hand		Left Hand		Right Hand		Left Hand	
Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)	Crimp(%)	Take-up(%)
60 Gram Warp				60 Gram Filling			
12.5	11.2	11.6	10.4	12.6	11.2	13.0	11.4
12.8	11.4	13.0	11.5	11.8	10.6	13.6	12.0
13.6	12.0	11.2	10.0	13.0	11.4	12.4	11.0
12.6	11.2	12.2	10.8	12.8	11.4	13.2	11.6
12.6	11.2	11.6	10.4	12.3	11.1	13.6	12.0
12.8	11.4	11.6	10.4	12.8	11.2	12.6	11.2
12.4	11.0	11.0	10.0	12.6	11.2	13.8	12.2
13.6	12.0	11.0	10.0	13.6	12.2	14.0	12.2
12.78	11.37	12.07	10.76	12.79	11.36	13.18	11.62
70 Gram Warp				70 Gram Filling			
11.0	9.8	12.4	11.0	14.8	12.8	12.8	11.2
12.6	11.2	12.6	11.2	13.8	12.2	12.2	11.0
12.4	11.0	13.6	12.0	12.8	11.3	14.0	12.2
10.8	9.8	12.8	11.4	12.4	11.0	13.8	12.0
10.6	9.8	12.4	11.0	12.6	11.2	12.0	11.4
10.4	9.4	12.2	10.8	13.4	11.8	12.0	10.8
12.2	10.8	12.6	11.2	13.8	12.0	13.2	11.6
10.6	9.6	13.0	11.4	11.2	10.2	11.6	10.4
12.4	11.2	12.0	10.8	12.2	10.8	12.4	11.0
11.2	10.2	12.6	11.2	14.0	12.2	11.6	10.4
12.4	11.2	12.6	11.2	13.6	12.0	12.6	11.2
11.8	10.6	12.8	11.4	13.6	12.2	12.8	11.4
12.4	11.2	12.0	10.8	13.6	12.0	13.8	12.2
10.6	9.6	12.6	11.2	13.0	11.6	14.0	12.2
11.2	10.2	12.0	10.8	13.5	11.9	13.0	11.5
11.6	10.4	12.4	11.0	12.8	11.4	12.0	10.8
10.6	9.6	11.2	10.2	13.6	12.0	14.0	12.3
11.6	10.4	11.0	10.0	12.8	11.4	12.4	11.0
12.6	11.2	12.4	11.0	13.4	11.8	12.2	11.0
11.2	10.0	12.4	11.0	13.8	12.0	12.8	11.2
11.51	10.41	12.38	11.03	13.13	11.69	12.76	11.34

Table 25. Effects of Tension on Greige Ravelled Strip Breaks

Right Hand		Left Hand		Right Hand		Left Hand		Right Hand		Left Hand	
Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)
40 Gram Warp				40 Gram Filling				50 Gram Warp			
94	.60	108	.60	78	.50	85	.48	113	.62	115	.52
103	.62	105	.50	75	.50	85	.48	115	.57	108	.50
106	.60	104	.67	82	.48	84	.45	124	.53	113	.54
99	.55	107	.64	82	.48	83	.44	119	.50	115	.54
104	.60	115	.60	84	.50	80	.47	117	.50	110	.50
113	.60	116	.71	83	.50	80	.48	113	.50	113	.52
111	.55	116	.60	83	.49	84	.48	117	.57	106	.58
111	.58	96	.60	81	.48	79	.47	117	.52	116	.58
108	.50	114	.65	82	.45	80	.40	117	.52	106	.53
100	.60	111	.59	83	.49	80	.40	118	.53	114	.54
95	.62	113	.58	82	.45	80	.40	119	.58	115	.53
95	.60	114	.60	80	.49	74	.42	121	.57	102	.50
109	.58	114	.60	77	.42	68	.49	117	.50	110	.52
97	.60	115	.56	77	.45	72	.49	115	.50	113	.53
102	.60	99	.60	77	.48	84	.43	120	.50	113	.54
108	.59	97	.52	84	.50	78	.50	118	.50	107	.52
105	.55	92	.60	83	.50	87	.48	123	.56	104	.52
107	.60	97	.60	73	.50	84	.48	118	.52	113	.54
110	.60	104	.62	81	.48	87	.48	116	.53	113	.54
104	.60	103	.70	83	.50	88	.49	117	.53	107	.56
104.0	.592	107.0	.607	80.5	.482	81.1	.464	117.7	.532	110.7	.532

(Continued)

Table 25. Effects of Tension on Greige Ravelled Strip Breaks (Continued)

Right Hand		Left Hand		Right Hand		Left Hand		Right Hand		Left Hand	
Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)
50 Gram Filling				60 Gram Warp				60 Gram Filling			
78	.49	83	.50	113	.52	108	.50	87	.50	88	.50
82	.48	84	.48	117	.50	110	.50	85	.50	87	.50
88	.48	87	.48	122	.51	110	.50	87	.50	74	.46
81	.47	86	.50	117	.50	110	.52	87	.48	80	.42
80	.47	84	.50	123	.52	117	.52	85	.48	78	.47
85	.45	88	.50	119	.50	113	.50	87	.48	81	.50
77	.45	88	.50	115	.50	110	.52	77	.49	73	.45
80	.43	86	.50	118	.50	118	.50	83	.47	74	.50
90	.50	90	.47	122	.50	118	.52	82	.50	82	.50
83	.48	90	.48	118	.50	112	.50	85	.50	87	.50
85	.50	84	.50	113	.50	115	.52	83	.50	80	.50
82	.50	84	.50	117	.50	115	.54	86	.50	84	.50
83	.45	80	.50	115	.52	115	.52	88	.50	77	.48
97	.50	80	.50	127	.53	117	.50	91	.52	84	.48
85	.50	87	.50	123	.51	110	.54	78	.47	83	.49
81	.47	82	.50	117	.50	113	.54	87	.48	86	.49
87	.50	83	.48	124	.50	.22	.50	87	.50	78	.50
80	.45	80	.48	118	.52	114	.50	88	.50	87	.50
82	.47	88	.50	126	.50	110	.54	82	.52	82	.50
86	.50	88	.48	123	.50	112	.60	87	.50	80	.52
83.6	.477	85.1	.492	119.3	.506	113.4	.519	89.2	.494	81.2	.488

(Continued)

Table 25. Effects of Tension on Greige Ravelled Strip Breaks (Continued)

Right Hand		Left Hand		Right Hand		Left Hand	
Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)	Break (lbs)	Elongation (in)
	70 Gram Warp						
104	.52	125	.53	98	.50	83	.50
117	.53	120	.50	91	.52	79	.48
110	.50	117	.50	93	.52	82	.51
121	.51	118	.49	87	.50	85	.50
121	.52	118	.49	87	.50	87	.50
123	.53	121	.50	84	.49	93	.50
121	.50	121	.50	78	.48	87	.50
118	.49	121	.50	89	.52	90	.56
114	.49	118	.50	91	.52	86	.50
125	.50	124	.50	95	.51	85	.50
117	.50	121	.51	94	.52	82	.50
115	.51	120	.50	94	.52	87	.50
120	.52	116	.50	89	.51	90	.52
114	.51	116	.48	85	.51	95	.52
114	.51	125	.50	83	.49	85	.53
117	.50	123	.50	84	.50	85	.52
117	.48	117	.48	83	.50	86	.50
108	.48	116	.48	86	.51	87	.52
120	.51	107	.50	83	.51	93	.52
113	.50	106	.49	88	.51	89	.51
115.9	.505	118.7	.498	88.1	.507	86.8	.508

Table 26. Effects of Tension on Sanforized Ravelled Strip Breaks

Right Hand		Left Hand		Right Hand		Left Hand	
Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)
40 Gram Warp				40 Gram Filling			
110	.80	100	.75	73	.60	27	.42
79	.60	98	.65	86	.70	75	.65
104	.65	93	.65	80	.73	27	.47
109	.65	100	.63	80	.68	26	.47
94	.62	110	.68	79	.63	76	.62
104	.62	110	.64	82	.68	78	.62
101	.60	103	.63	75	.69	27	.65
97	.65	99	.60	77	.63	79	.67
105	.47	95	.63	74	.62	78	.69
104	.64	100	.62	80	.63	77	.64
87	.65	110	.67	77	.63	90	.71
100	.61	95	.60	77	.67	85	.70
108	.65	110	.60	87	.62	87	.70
103	.65	108	.63	73	.63	88	.65
101	.68	103	.61	94	.68	84	.70
91	.60	105	.62	77	.63	36	.50
97	.63	105	.62	77	.60	76	.65
84	.60	101	.62	74	.62	79	.64
107	.62	117	.65	78	.72	83	.63
101	.60	104	.64	80	.75	84	.68
99.3	.629	103.7	.638	79.0	.657	68.1	.623

(Continued)

Table 26. Effects of Tension on Sanforized Ravelled Strip Breaks (Continued)

Right Hand		Left Hand		Right Hand		Left Hand	
Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)
	50 Gram Warp				50 Gram Filling		
90	.62	105	.68	85	.80	91	.88
104	.62	96	.58	83	.82	87	.90
104	.62	117	.67	88	.85	85	.80
103	.62	103	.62	83	.80	87	.80
107	.58	114	.68	85	.78	83	.80
101	.66	110	.62	78	.72	94	.80
98	.67	112	.65	77	.72	80	.72
104	.70	115	.65	79	.68	82	.72
108	.62	118	.70	85	.75	83	.78
111	.63	117	.64	90	.78	88	.80
111	.65	112	.64	78	.68	88	.80
96	.55	102	.62	77	.80	88	.78
108	.62	113	.61	89	.84	88	.78
107	.64	113	.62	82	.80	89	.80
114	.72	107	.68	82	.80	92	.82
98	.63	112	.68	84	.80	84	.78
103	.60	113	.64	85	.80	86	.74
102	.62	108	.68	78	.80	86	.76
115	.69	111	.65	77	.78	88	.78
107	.62	110	.64	85	.90	85	.74
104.5	.634	110.4	.647	83.0	.785	86.7	.789

(Continued)

Table 26. Effects of Tension on Sanforized Ravelled Strip Breaks (Continued)

Right Hand		Left Hand		Right Hand		Left Hand	
Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)
	60 Gram Warp				60 Gram Filling		
113	.75	120	.70	88	.72	86	.74
112	.60	115	.72	90	.80	86	.68
114	.67	.26	.79	93	.88	86	.74
120	.72	121	.82	90	.88	91	.80
113	.70	116	.78	93	.88	82	.70
120	.72	118	.75	87	.80	91	.82
118	.82	120	.75	87	.80	84	.80
108	.72	116	.74	93	.78	100	.80
117	.72	112	.72	88	.80	77	.70
108	.70	113	.72	94	.87	86	.77
123	.70	117	.70	100	.90	87	.74
117	.72	125	.79	100	.85	93	.78
128	.74	117	.78	78	.80	88	.78
113	.72	123	.77	87	.84	94	.78
118	.68	117	.80	94	.88	92	.78
103	.73	123	.72	82	.82	86	.74
117	.70	113	.73	94	.88	94	.76
101	.68	107	.70	76	.80	87	.80
104	.68	120	.78	77	.80	92	.80
117	.78	117	.70	85	.80	88	.68
114.2	.712	117.8	.748	88.8	.829	88.5	.769

(Continued)

Table 26. Effects of Tension on Sanforized Ravelled Strip Breaks (Continued)

Right Hand		Left Hand		Right Hand		Left Hand	
Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)	Break(lbs)	Elongation(in)
	70 Gram Warp				70 Gram Filling		
120	.78	124	.78	90	.83	94	.88
120	.80	127	.80	87	.82	94	.88
125	.75	113	.70	93	.78	93	.88
123	.73	119	.78	92	.82	90	.88
113	.72	112	.72	97	.88	88	.80
107	.68	112	.70	95	.80	78	.74
125	.73	113	.72	93	.80	95	.81
116	.78	118	.70	93	.78	96	.78
120	.67	118	.78	89	.82	96	.80
114	.63	.24	.69	90	.88	97	.78
120	.72	113	.67	96	.86	91	.82
105	.68	124	.79	88	.82	87	.80
121	.73	123	.78	85	.80	97	.86
125	.78	111	.71	74	.73	93	.78
118	.72	118	.73	93	.80	87	.76
128	.78	118	.73	84	.78	88	.70
125	.70	118	.78	90	.76	83	.70
128	.70	124	.79	93	.80	90	.72
120	.73	107	.70	83	.73	88	.80
119	.72	117	.72	84	.78	84	.68
119.6	.726	117.6	.738	89.9	.804	90.4	.794

Table 27. Effects of Tension in Greige Shrinkage in Inches

Right Hand		Left Hand		Right Hand		Left Hand	
Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
	40 Grams				50 Grams		
16.51	17.10	16.50	17.00	16.35	17.05	16.40	16.90
16.38	17.10	16.65	17.05	16.40	17.05	16.45	16.90
16.25	17.15	16.55	17.05	16.25	17.00	16.40	17.00
16.32	17.21	16.60	17.10	16.38	17.10	16.40	17.00
16.35	17.20	16.65	17.02	16.45	17.15	16.55	16.95
16.50	17.15	16.50	17.15	16.35	16.90	16.45	17.05
16.55	17.15	16.48	17.15	16.30	17.00	16.45	17.15
16.55	16.95	16.45	17.20	16.21	17.00	16.40	17.05
16.55	17.10	16.30	17.18	16.20	17.10	16.45	17.10
16.55	17.20	16.32	17.10	16.15	17.05	16.60	17.01
16.55	17.10	16.55	17.00	16.38	16.90	16.68	17.05
16.50	17.00	16.45	16.90	16.30	16.95	16.61	17.08
16.55	17.05	16.55	17.00	16.25	16.95	16.70	17.10
16.52	17.00	16.45	17.00	16.28	17.00	16.55	17.25
16.50	17.18	16.50	17.05	16.35	16.95	16.45	16.90
16.47	17.11	16.50	17.06	16.31	17.01	16.50	17.03
	60 Grams				70 Grams		
16.50	17.10	16.15	17.10	16.10	16.95	16.15	16.90
16.40	17.15	15.90	17.05	15.95	16.90	16.25	16.90
16.40	17.20	15.95	17.00	16.05	16.85	16.00	17.00
16.38	17.05	15.95	17.00	16.18	16.90	16.00	17.00
16.40	17.15	16.15	16.98	16.10	17.10	16.10	17.00
16.50	17.20	16.50	17.00	16.30	17.20	16.30	16.80
16.45	17.20	16.25	17.00	16.20	17.18	15.90	16.85
16.50	17.12	16.35	16.90	15.95	17.28	15.90	16.90
16.55	17.05	16.30	16.95	16.20	17.30	16.00	16.90
16.50	17.05	16.22	16.95	16.25	17.25	16.10	17.00
16.35	16.90	16.11	17.00	16.45	17.25	16.18	17.01
16.20	16.95	16.12	17.00	16.41	17.15	16.05	17.00
16.00	16.90	16.20	16.95	16.50	17.15	16.00	17.00
16.10	17.05	16.30	17.10	16.50	17.15	16.04	17.00
16.18	17.00	16.30	17.15	16.40	17.15	16.30	17.02
16.36	17.07	16.18	17.01	16.24	17.11	16.08	16.96

Table 28. Effects of Tension on Sanforized Shrinkage in Inches

Right Hand		Left Hand		Right Hand		Left Hand	
Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
	40 Grams				50 Grams		
18.20	17.85	18.62	17.90	18.28	18.95	18.35	17.95
18.20	17.80	18.55	17.90	18.28	18.05	18.35	17.95
18.28	17.85	18.50	17.85	18.28	18.00	18.38	17.85
18.28	17.85	18.55	17.85	18.18	18.02	18.37	17.90
18.30	17.80	18.58	17.90	18.32	18.04	18.35	18.00
18.55	17.80	18.55	17.85	18.38	18.05	18.55	17.95
18.50	17.82	18.50	17.75	18.45	18.00	18.50	17.95
18.50	17.90	18.53	17.70	18.50	17.95	18.45	17.95
18.50	17.85	18.52	17.75	18.45	18.00	18.40	17.90
18.45	17.90	18.52	17.75	18.35	18.00	18.45	17.95
18.45	17.75	18.50	17.80	18.50	17.90	18.50	17.95
18.35	17.75	18.48	17.75	18.55	18.05	18.45	17.95
18.28	17.80	18.50	17.75	18.45	18.00	18.40	18.00
18.35	17.78	18.55	17.80	18.35	17.95	18.45	17.95
18.40	17.80	18.55	17.85	18.37	18.05	18.43	17.90
18.37	17.82	18.53	17.81	18.38	18.01	18.42	17.93
	60 Grams				70 Grams		
18.35	18.00	18.40	18.00	18.40	18.10	18.38	18.01
18.35	18.05	18.35	18.10	18.35	18.03	18.40	18.02
18.35	18.10	18.32	18.05	18.42	18.00	18.39	18.06
18.40	18.10	18.35	17.95	18.36	17.97	18.36	17.95
18.40	18.15	18.31	18.05	18.28	18.08	18.40	18.00
18.30	18.05	18.35	18.00	18.27	17.95	18.41	17.99
18.38	18.02	18.40	18.00	18.38	17.91	18.40	17.94
18.56	18.00	18.45	18.05	18.35	17.92	18.28	17.95
18.43	18.10	18.42	18.00	18.35	17.93	18.31	17.95
18.40	18.05	18.35	18.00	18.40	17.98	18.50	17.90
18.40	18.05	18.35	18.00	18.32	18.00	18.45	17.85
18.38	18.00	18.40	18.10	18.36	18.00	18.45	17.88
18.35	18.05	18.39	18.00	18.33	17.93	18.45	17.95
18.40	18.00	18.35	18.05	18.31	17.95	18.45	18.00
18.38	18.10	18.36	18.00	18.35	18.01	18.40	17.90
18.39	18.06	18.37	18.02	18.35	17.96	18.40	17.94

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