SERVICEABILITY OF CERTAIN RAYON FABRICS AS DETERMINED BY LABORATORY TESTS

by

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INTRODUCTION

Rayon, the modern, scientifically-made textile, represents one more field in which man has altered nature for his purposes. From a weak imitation of a natural fiber, rayon has advanced to an important place as a distinct and separate textile among the major textile fibers. Twenty-five years ago, the industry was a small struggling one. Today, in America alone, the production of rayon yarns has advanced to a point where their production and consumption will be in the neighborhood of 275,000,000 pounds or almost three times the total world's production of silk, according to Salvage (10) in 1936-37. In the United States in 1936 there were 25 producers of rayon, 19 by the viscose process, 4 by the acetate, and 2 by the cuprammonium, according to Schwarz and Mauersberger (11).

They were:

Viscose Process

Acme Rayon Corporation	North American Rayon Corporation
American Enka Corporation	Skenandoa Rayon Corporation
Delaware Rayon Company	Tubize Chatillon Corporation
DuPont Rayon Company	American Viscose Corporation
Hampton Company	Woonsocket Rayon Corporation
Hartford Rayon Corporation	Industrial Rayon Corporation
New Bedford Rayon Company	

Acetate Process

Celanese Corporation of America
DuPont Rayon Corporation
Tennessee Eastman Corporation
American Viscose Corporation

Cuprammonium Process

American Bemberg Corporation
New Process Rayon, Inc.

A fourth process, the nitro-cellulose, had been in use in the United States; but in 1934, the Tubize Chatillon Corporation, the only producers of nitro-cellulose rayon yarns in America, closed its nitro plant, discontinuing, for the present at least, the nitro process in America.

In 1934, 77.5 per cent of the rayon yarn was produced by the viscose process and 19 per cent by the acetate process, leaving 3.5 per cent to be divided between the cuprammonium and nitro-cellulose processes. Twenty million pounds of rayon yarn were used in the manufacture of woven goods underwear, and only 5,500,000 pounds of silk yarn in 1937 (9). Stated in another way, the comparison is 125,000,000 yards of rayon fabrics were used as underwear fabrics in comparison to 45,000,000 yards of silk fabrics. The estimated relative importance of the various textiles in women's wear in 1937 was: cottons,72 per cent; rayons, 18 per cent; wools, 5 per cent; silks, 4 per cent; and linens, 1 per cent. These figures are quoted from Rayons at Retail (9).

Rayons have become increasingly popular as lingerie fabrics. In January 1937, tradesmen expressed the belief that acetate satin, particularly for lingerie purposes, was due for an increasingly important place in the industry. Acetate satin is preferred for slips by some lingerie houses because of its sleekness and soft hand. In the preceding season, acetate slips had started as important, but had been forced from this position by the viscose process slip (7). Rayon filled silk-warp satin cloth, made with cuprammonium rayon, has been so popular this season as lingerie cloth that the manufacturers were unable to meet the demand for cuprammonium yarn, and acetate yarn was substituted according to Wenrich (16).

Some of the advantages of rayon are the variety of effects which may be achieved with the rayon yarns by varying twist, luster, fineness or coarseness of yarn, or other factors (9). Rayon fabrics have a wide price range with many comparatively inexpensive fabrics. White rayons do not turn yellow as do silks.

One of the chief advantages claimed for rayon fabrics is that they are not weighted to any extent. LeRoy[1] said that one of the reasons most often advanced for the use of rayon materials instead of fabrics of other fibers is that rayons are not weighted. Mauersberger[2] stated that practically no tin or lead weighting was being done on rayons, and that the presence of extraneous and non-fibrous finishing materials resolves itself into compounds of sulphonated, colorless oils, and in some cases, gums and starches. According to the Farr Alpaca Company[3], rayons are not weighted, the only sizing that is put on, is on the warp to assist in the weaving, and this size comes out in the boil-off process during finishing. Snowden[4] stated, "In so far as I know, no woven rayon goods have been weighted with metallic weighting. A few years ago there was considerable discussion as to metallic weighting of knit rayon goods, and it was claimed that there was considerable metallic weighting being done on this type of fabric. At the present time there is quite a vogue for

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[1]Letter from C.H. LeRoy, Rayon Yarn Producers Group. May 6, 1938.

[2]Letter from Herbert R. Mauersberger, Textile Consultant. May 2, 1938.

[3]Letter from the Farr Alpaca Co. April 29, 1938.

[4]Letter from Bruce Snowden, Celanese Corp. May 5, 1938.

different types of finishes which are supposed to add something to the property of the fabric. We have experimented with various types of such finishes but have never adopted them for our fabrics, inasmuch as it has been our claim that such finishes detract from the value of the fabric, as the original hand of the fabric is thus lost and also they have not in our experience, enhanced the value. Consequently, we have never weighted or added finishes to our fabrics. You will find the fabric sent you has no weighting of any type." Ekstrom (4) found that most fabrics used in silk slips were weighted to the extent that serviceability may be lessened.

Disadvantages claimed for rayon fabrics are those due to the lack of elasticity and high ductility of the rayon fibers, the lack of twist in the yarn resulting in the fraying and pulling out of the fabrics, the loss of strength when wet, and the melting of acetate when ironed at a high temperature.

Such closely woven rayon fabrics as taffetas possess the disadvantages of all closely woven fabrics in that they prevent the passage of air and therefore tend to retain body heat.

Improvement of the characteristics of rayon yarns in order that rayon fabrics will compare favorably or surpass fabrics made from the natural fibers has lead manufacturers to engage in extensive research. Tensile strength, elasticity, ability to take dyes, non-slip and anti-crease finishes have all occupied the attention of rayon companies' research workers, but the consumer has not had the benefit of research to provide him a basis upon which a wise choice of materials might be made.

Techniques and methods of tests have continued to be developed by the various rayon manufacturers to control their own production, but little of this has been published according to the United States Testing Company (17). They state that due to the awakening of consumer consciousness to his buying problems, commercial laboratories have developed tests for rayon to help meet the need for information that will aid him in making his choices. The emphasis placed recently by the consumer on the dissatisfaction arising from the slippage of threads has led to the working out, by the American Society for Testing Materials, of a method for testing resistance to slippage. That resistance to slippage is an important factor in the serviceability of a garment is the opinion of Simon (13). He says, "Of the many complaints received by retail stores that sell women's garments, a high percentage are due to the fabric slipping at the seams. This is an extremely important factor in dress fabrics, as well as in lingerie, for upon it, to a great extent, depends the serviceability of the garment."

The strength of synthetic materials in the form of continuous filament yarns is less than those of cotton, silk, and schappe silk yarns, according to Allen (1). If equally strong fabrics are to be produced, those consisting of rayon must be decidedly heavier than those of thrown silk, schappe silk or cotton. Thus when obtained in rayons the pebble or crepe effect is of a definitely coarser type than that of thrown silk crepe. It is easier to exceed the elastic limit in rayon yarns and filaments than in silk or cotton, and the pronounced plasticity of rayon in comparison with silk or cotton renders the manufacture of rayon crepes really difficult compared with that of silk crepes. He stated that even in the newest varieties of rayon the elastic properties are not equal to those of the natural fibers.

Tests showed the synthetic fabrics to be as seriously in need of standardization and correct labeling as silk fabrics, in a report by Mack (8) of a study of rayon and other synthetic fabrics on the market from 1932 through

1935. Fletcher[5] (1938) found that information in regard to the three types of rayon whether given on the label or by the salesperson was the least accurate of any about fabrics made of one fiber. The fabrics were seldom named as viscose, cuprammonium, or cellulose-acetate rayons. In her study of 135 mixed fabrics she found that very little information was obtained concerning the percentage of fiber content and the kind of fiber present either from the label or from the salesperson. In recognition of inadequacy of labeling, the Federal Trade Commission promulgated in October, 1937, the Rayon Trade Practice Rules for the express purpose of providing for "proper fiber identification and disclosure of rayon products and for the prevention of misinformation, misrepresentation and deception, in the interest of fair competition and consumer protection." Rayon must be clearly labeled and sold as rayon with no attempt to disguise the fact. In mixed goods, full non-deceptive disclosure of the rayon and other fibers present should be made according to the Commission (5).

Comparatively little effort has been made to educate the consumer as to what rayons really are and what their

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[5] Study done by Hazel Fletcher, Kansas State College, 1938.

good qualities are according to Freedman (6). He says that the consumer must be supplied with information essential to the proper evaluation and care of her purchases.

The purpose of this study was to compare by means of breaking strength, yarn slippage, and shrinkage the serviceability of representative plain and satin weave rayon fabrics made from both viscose and cellulose-acetate yarns; and to determine in so far as possible by laboratory tests, the rayon fabric most satisfactory for women's service garments.

STATUS OF KNOWLEDGE

Although the serviceability of rayon fabrics is often questioned by consumers, few studies of their wearing qualities have been made.

In a study of the wearing qualities of lining fabrics made from synthetic yarns, Simon (12) concluded that, in so far as the wearing quality was related to the kinds of fibers used, all-acetate fabrics were superior to acetate-warp, viscose-filled fabrics; and that acetate-warp, viscose-filled fabrics were superior to all-viscose. He found, however, that a single sample of all-viscose might outwear a single sample of all-acetate in identical construction and color.

Dodson (3) tested 82 silk and rayon dress fabrics believed to be typical of those in use for women's dresses during the fall and winter of 1935-1936. All the fabrics with the exception of one piece of chiffon were above 30 pounds in warp and 20 pounds in filling strength, which she regarded as a highly satisfactory rating. In 10 rayon fabrics, the highest rated 86.5 pounds warpwise and 47.2 pounds fillingwise, while the lowest was 46.0 pounds warpwise and 44.2 pounds fillingwise, with the average 61.75 pounds warpwise and 44.81 pounds fillingwise. Of 22 rayon and acetate fabrics, a novelty nub crepe-back satin rated highest at 98.8 pounds warpwise and 35.2 pounds fillingwise; the lowest was 35.5 pounds warpwise and 30.8 pounds fillingwise, with the average 56.50 pounds warpwise and 34.18 pounds fillingwise. It is not stated what type of rayon, whether viscose, cuprammonium, or acetate, is meant when the term "rayon" is used in the study. When tested for slippage, the twenty pieces of pure dye silk averaged 21.26 pounds; the weighted silk, 19.17 pounds; the rayon, 15.07 pounds; the acetate, 16.00 pounds; the acetate and rayon, 17.12 pounds, and the miscellaneous mixture, 18.75 pounds. Shrinkage from "cleaning-dry" was 2.01 per cent in the warp and 2.01 per cent in the filling for the rayons; and 1.25 per cent in the warp and 1.30 per cent in the filling for the acetates. Dodson concluded that "upon comparing fabrics classified by fibers, it would seem that reasonable serviceability may be expected from fabrics whether pure dye or weighted silk, rayon or acetate, other factors taken into consideration."

Smith[6] made a study of slip materials as a basis for the selection of slip fabrics by high school girls. She concluded that cheap rayons do not wear well or look well and are difficult to make up; and that it is much better to buy a good grade of rayon than a poor grade of silk. A study by Nelson[7] of the relationship of price to service for rayon bias slips indicated that with each successive increase in the original cost of the slips, from $0.49 to $1.69, there was a great increase in serviceability with a corresponding decrease in cost per hour of wear.

A study is in progress at the present time on the seam strength of rayon goods. Three types of slips are being

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[6]Study made by Daphyne Smith (1936), filed in Clothing and Textiles Department, Kansas State College.

[7]Study made by Esther Bruner Nelson (1937), filed in Clothing and Textiles Department, Kansas State College.

worn by one thousand women. Results are not yet available.[8]

PROCEDURE

Difficulties Encountered in the Selection of Fabrics

The original plan was to secure only plain weave white rayon fabrics made from viscose, acetate, and cuprammonium yarns, both lustrous and delustered, and made from continuous filament and staple fibers.

Fabrics made from cuprammonium were omitted from this study because, according to the statement of the American Bemberg Corporation,[9] their yarns are used chiefly in combination with silk to make satin slip materials. The New Process Rayon, Inc., the only producer of cuprammonium yarn other than the American Bemberg Corporation, did not reply to requests for information about their products and nothing designated as their product could be found on the market. C. H. LeRoy[10] of the Rayon Yarn Producers Group, stated, "I am not entirely familiar with the operations of the New Process Rayon, Inc. as they are not members of

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[8]Study being made by Alexis Sommaripa, manager of the Fabric Development Department of E.I. DuPont Nemours & Co. in cooperation with Sears, Roebuck and Montgomery Ward& Co. (1938).

[9]Letter from American Bemberg Corporation,New York C., January 19, 1938.

[10]Letter from C. H. LeRoy, New York City, May 6, 1938.

this Group. To the best of my knowledge they are in production and the process is cuprammonium." However, since it seemed impossible to get a slip fabric at present made from all cuprammonium yarns, it had to be eliminated from the plan.

The spun rayons were eliminated because it was found that at present they are not in use for women's service garments, and that spun rayon yarns are not made by many of the prominent rayon companies. The J. P. Stevens & Company, Inc.[11] said, "As yet spun rayon yarns are not used for the manufacture of women's slips." The United States Testing Company[12] said, "We have checked with several large manufacturers of women's slips and to our knowledge spun rayon is not used in the manufacture of slips at the present time." The American Bemberg Corporation[13], The North American Rayon Corporation[14], The Woonsocket Rayon Company (subsidiary of Manville Jenckes Corporation)[15],

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[11]Letter from J. P. Stevens & Company, Inc., Commission Merchants, April 6, 1938.

[12]Letter from the United States Testing Company, Hoboken, New Jersey, March 29, 1938.

[13]Letter from the American Bemberg Corporation, New York City, Feb. 28, 1938.

[14]Letter from the North American Rayon Corporation, New York City, April 4, 1938.

[15]Letter from the Manville Jenckes Corporation, Manville, R. I., March 18, 1938.

and the Celanese Corporation[16] stated that they do not make spun rayon yarns.

Selection of Fabrics

After much correspondence with the rayon companies and their converters, it was concluded that satins and taffetas were the chief fabrics used in the commercial manufacture of slips, since the Celanese Corporation, Cohn-Hall-Marx Company, Bloomsbury Silk Mill, Farr Alpaca Company, J. P. Stevens & Company, Inc., The Fiatelle Company, N. Fluegleman & Company, Inc., and the Palisade Mills all sent taffetas and satins when requested for samples of representative slip materials. Cohn-Hall-Marx[17] stated, "Most manufacturers of slips today have been using taffetas and satins in large quantities." A few samples of plain weave delustered crepes were sent, so a delustered viscose and a delustered acetate crepe were included in this study.

Six pieces of material and two slips were finally secured from the rayon producers or their converters; three

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[16] Letter from the Celanese Corporation, New York City, Feb. 28, 1938.

[17] Letter from Cohn-Hall-Marx, New York City, Feb. 28, 1938.

pieces of material were purchased in the local stores, and another piece was purchased in a Kansas City, Missouri, store. The fabrics were all moderately priced, varying from $0.21 a yard to $0.69 a yard. Some of the prices are wholesale, others retail. Their width varied from 38 to 41½ inches. Table 1 indicates the source, price, and width of each material. Six viscose fabrics were secured: one crepe, three satins, and two taffetas; likewise, six acetate fabrics: one crepe, two satins, and three taffetas. Two and one-half yard swatches were used. An attempt was made to secure fabrics of like construction in similar thread count. In Plates I and II samples of each material are presented. Each of the fabrics tested is designated by letters from A to L inclusive.

Analysis of Fabrics

The fiber content of the fabrics was identified microscopically from cross-sections of the fibers which had been imbedded in cork and mounted in glycerine. Camera lucida drawings were made of the warp and filling yarns of each fabric.

Twist of the yarns was determined on a Suter twist counter by the method outlined by Committee D-13 On Textile

Table 1. The fabrics chosen with their source, price per yard, and width in inches.

Fabric	Source	Price per yard	Width in inches
A. Faille taffeta, acetate	Cohn-Hall-Marx Co., New York City	0.21	38
B. Faille taffeta, viscose	Cohn-Hall-Marx Co., New York City	0.21	39
C. Crepe, viscose	Ward-Keller, Manhattan, Kans.	0.59	38
D. Crepe, acetate	Celanese Corp. of America, N. Y. City	0.47½	38
E. Satin, acetate	Celanese Corp. of America, N. Y. City	0.40	38
F. Satin, viscose	Farr Alpaca Company, Holyoke, Mass.	0.49	40
G. Taffeta, acetate	Celanese Corp. of America, N. Y. City	No charge	41½
H. Taffeta, acetate	J. C. Penney Co., Manhattan, Kans.	0.69	40
I. Taffeta, viscose	Jones Store, Kansas City, Mo.	0.25	38
J. Satin, viscose	Cole's Store, Manhattan, Kans.	0.69	39
K. Satin, viscose (slip)	E.I. DuPont DeNemours & Co., N.Y.City	No charge	--
L. Satin, acetate (slip)	E.I. DuPont DeNemours & Co., N.Y.City	No charge	--

EXPLANATION OF PLATE I

Samples of Fabrics Used

Fig. 1. A, faille taffeta, acetate.

Fig. 2. B, faille taffeta, viscose.

Fig. 3. C, crepe, viscose.

Fig. 4. D, crepe, acetate.

Fig. 5. E, satin, acetate.

Fig. 6. F, satin, viscose.

Plate I

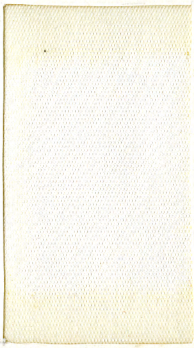

Fig. 1

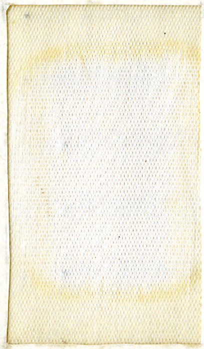

Fig. 2

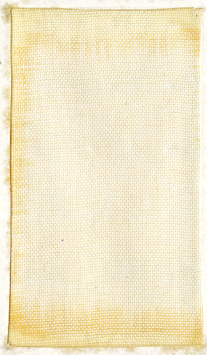

Fig. 3

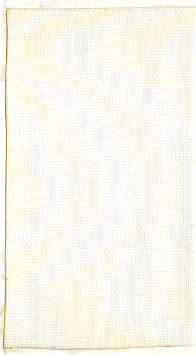

Fig. 4

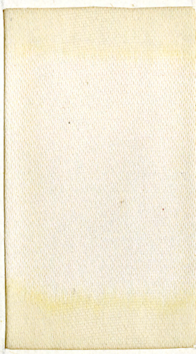

Fig. 5

Fig. 6

EXPLANATION OF PLATE II

Samples of Fabrics Used

Fig. 7. G, taffeta, acetate.

Fig. 8. H, taffeta, viscose.

Fig. 9. I, taffeta, viscose.

Fig. 10. J, satin, viscose.

Fig. 11. K, satin, viscose.

Fig. 12. L, satin, acetate.

Plate II

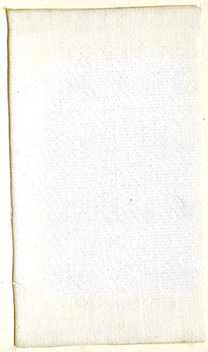
Fig. 7

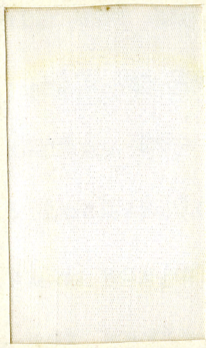
Fig. 8

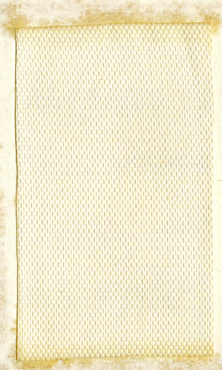
Fig. 9

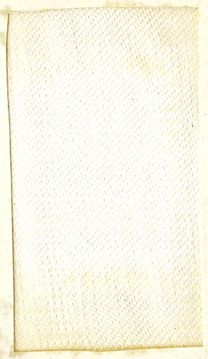
Fig. 10

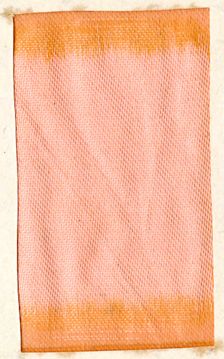
Fig. 11

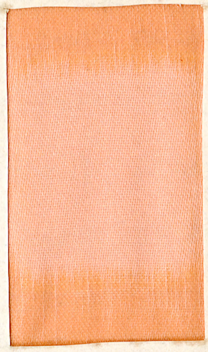
Fig. 12

Materials (2), D 276-37 T.

Tests for Serviceability

The breaking strength of the fabrics was tested warpwise and fillingwise, both wet and dry, by the grab method designated by Committee D-13 On Textile Materials (2) as D 415-35 T. For each fabric, two sets of six specimens, each 4 inches wide and 6 inches long, were cut, one set having the longer dimension warpwise to test warp breaking strength, and the other set having the longer dimension fillingwise for the filling breaking strength. No two specimens contained the same set of yarns. Six specimens, three for warp strength and three for filling, were conditioned for 4 hours at standard atmospheric conditions. (Standard condition is regarded as 65 per cent relative humidity at 70 F. with a ± 2 per cent tolerance in relative humidity and plus 10 F. in temperature.) After conditioning for 4 hours, the six specimens were broken in the Scott Tester. The remaining six specimens were immersed in tap water at room temperature for 2 hours. They were then removed from the water, one at a time, and tested immediately for breaking strength in the same manner as the dry specimens. The averages of the warp and filling strengths, respectively, both wet and dry, were recorded. Bias breaking strength was determined in a similar manner using three specimens cut on the true bias for determining the dry breaking strength and three for the wet breaking strength.

The resistance to yarn slippage was determined by test method D 434-36 T of Committee D-13 On Textile Materials (2). Resistance to slippage is defined as the pounds pull across a seam per one inch of width necessary to produce an elongation of $\frac{1}{4}$ inch in excess of the normal stretch of the fabric under the same load. Preliminary tests were made by pulling the fabric between the thumb and forefinger to determine the direction in which the smaller force was required to produce slippage. The force required was smaller, in every case, to produce slippage of warp threads on the filling.

Each specimen was prepared by cutting two pieces of fabric, one 4 by 4 inches and one 4 by 10 inches, cut with the long sides parallel to the filling yarns. The 4 by 4 inch piece was laid on the 4 by 10 inch piece in such a manner that the filling yarns in each piece ran in the same direction. The pieces were sewed together across the 4-inch end, $\frac{1}{2}$ inch from the end with a needle 0.030 inches in diameter and with No. 00 white mercerized thread. Fourteen stitches to the inch were used. Five specimens of each fabric were prepared thus, and conditioned for four hours at standard conditions. They were then ready for testing on the Scott Tester.

The 4 by 10 inch piece of the specimen was clamped in the jaws of the tester, the pen set at the zero-zero point on the chart, the machine started and the load-elongation curve autographically recorded. The same specimen was again placed in the jaws with the seam located midway between the upper and lower jaws. With the pen again at the zero-zero point, the machine was started and the load-elongation curve autographically recorded. The resulting chart was placed over a Scott Tester poundage chart in such a manner that the vertical ordinates and the abscissas of each chart were superimposed. A pair of dividers was set at the points B and C (Figure 1) where the two curves cross the 1-pound ordinate. This distance between the two curves is called the "compensation." The dividers were then placed on a scale and opened $\frac{1}{2}$ inch farther which is the distance corresponding to $\frac{1}{4}$ inch slippage if the machine is adjusted for a 2:1 ratio of magnification. With the dividers set thus, they were moved out

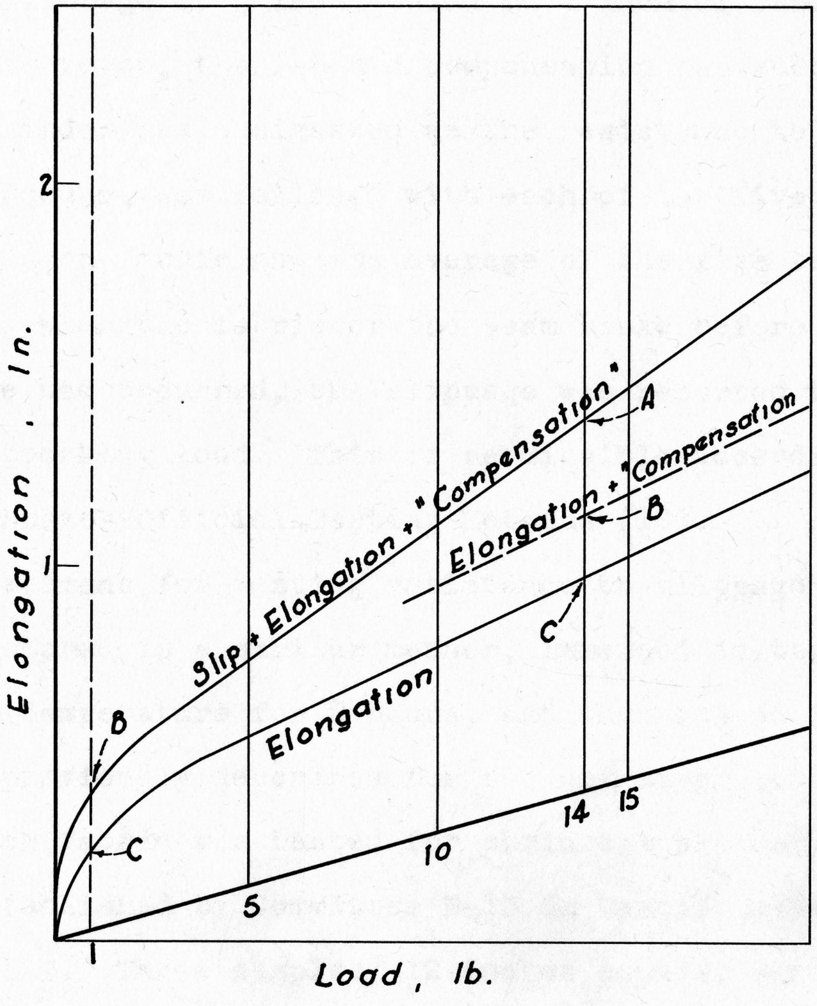

Fig. 1.-Slippage Chart

A to B = Distance equivalent to $\frac{1}{4}$-in. slip
B to C = "Compensation" at 1 lb.
Slippage of fabric was at 14-lb. reading, or
14 - 1 = 13 lb. per in., corrected.

until they reached the vertical ordinate at which each point of the divider rested on a point of the curves. The force in pounds at this position was that necessary to produce a slippage of $\frac{1}{4}$ inch, based on 1 inch of fabric width. From this force, the 1-pound compensation was subtracted. The remainder was designated as the resistance to slippage. This procedure was followed with each of the five specimens of each fabric and the average of the five tests recorded. When the fabric or the seam broke before $\frac{1}{4}$ inch slippage had occurred, the slippage was reported to be that of the breaking load. This is permissible according to United States Official Testing Methods (18).

Specimens for testing resistance to slippage when wet, were prepared in a similar manner, immersed in tap water at room temperature for 2 hours, and then tested in the manner previously described for the dry samples.

Each fabric was tested for shrinkage by the method of test established by Committee D-13 On Textile Materials (2), D 416-35 T. Three samples, 12 inches square, were cut from each fabric. No two of the three samples included the same set of yarns. A 10-inch square was marked off on each sample by pulling yarns and running colored threads through the space from which the yarns had been pulled. Each sample was then placed in a pint jar containing 300 ml. of a 0.5 per cent soap solution made with Ivory Soap Flakes. This solution and the rinse water was kept at a temperature of 100 F. ±2. The jar was placed in the Launder-Ometer. The water in the Launder-Ometer was maintained at 100 F.±2. The machine was operated for 15 minutes. Then the sample was removed from the jar, rinsed by dipping in three changes of water, returned to the jar with 300 ml. of water, and run in the machine for 5 minutes. The sample was removed, laid out on a table and the wrinkles smoothed out gently with the palm of the hand. While the sample was still damp, it was pressed with a flat-bed press just long enough to remove the moisture. The pressed sample was again laid on a table top for 2 hours at room temperature and humidity. At the end of this 2 hour period and before 16 hours had elapsed, the sample was measured. The shrinkage in the warp and in the filling was measured in three places, from corner to corner and through the mid-points of the sides, and the average calculated. The shrinkage was recorded in inches per yard and in percentage of the dimension before laundering.

FINDINGS AND DISCUSSION

Analysis of Fabrics

Typical photomicrographs of cross-sections of viscose fibers and acetate fibers are shown in Figures 2 and 3. Camera lucida drawings of the fibers of the fabrics used appear in Plates III-VIII inclusive.

The twist of the yarns was a right twist in every case, low in both warp and filling. It varied from 2.0 to 4.1 turns per inch in the warp, and from 1.6 to 4.4 in the filling.

The percentage of sizing and finishing materials present was low. It varied from 0.4 per cent to 5.2 per cent with an average of 1.37 per cent. Qualitative analyses were made of the three fabrics having the highest percentage of sizing and finishing materials. The others contained such small amounts that an accurate analysis would have been very difficult. Fabric C contained a filling material of the nature of China clay, talc, or gypsum, sulphonated oil, cane sugar, and gums; fabric I, cane sugar and gums; fabric K, glycerine and gums.

Among the fabrics studied, none showed a balanced construction. The thread count of the taffetas ranged from

Fig. 2

Fig. 3

Photomicrographs of typical cross-sections of viscose and acetate fibers (X350).

EXPLANATION OF PLATE III

Fig. 1. Camera lucida drawing of the warp cross-section of fabric A, (X600).

Fig. 2. Camera lucida drawing of the filling cross-section of fabric A, (X600).

Fig. 3. Camera lucida drawing of the warp cross-section of fabric B, (X600).

Fig. 4. Camera lucida drawing of the filling cross-section of fabric B, (X600).

Plate III

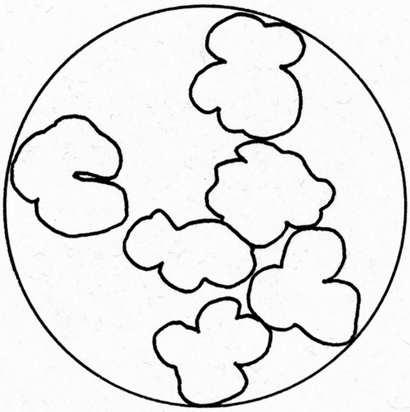

Fig. 1

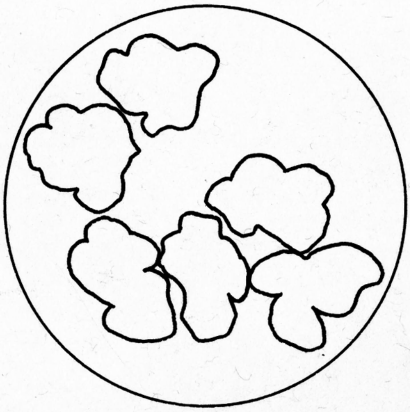

Fig. 2

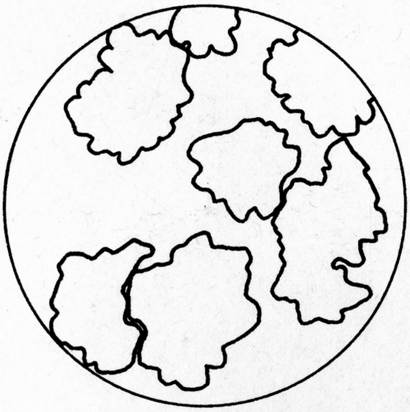

Fig. 3

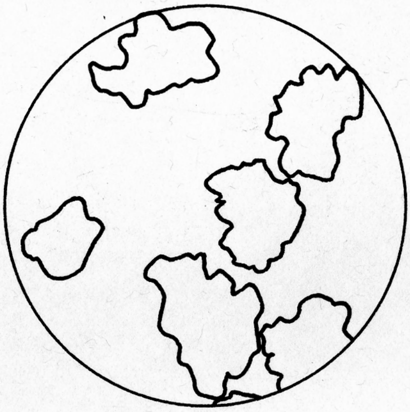

Fig. 4

EXPLANATION OF PLATE IV

Fig. 5. Camera lucida drawing of the warp cross-section of fabric C, (X600).

Fig. 6. Camera lucida drawing of the filling cross-section of fabric C, (X600).

Fig. 7. Camera lucida drawing of the warp cross-section of fabric D, (X600).

Fig. 8. Camera lucida drawing of the filling cross-section of fabric D, (X600).

Plate IV

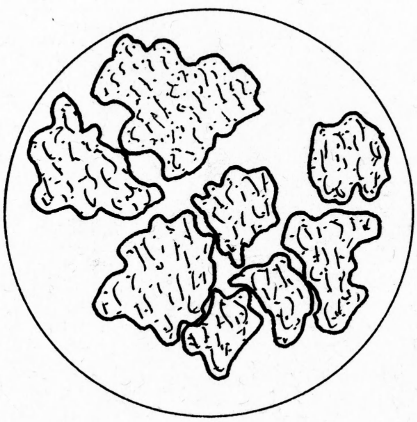

Fig. 5

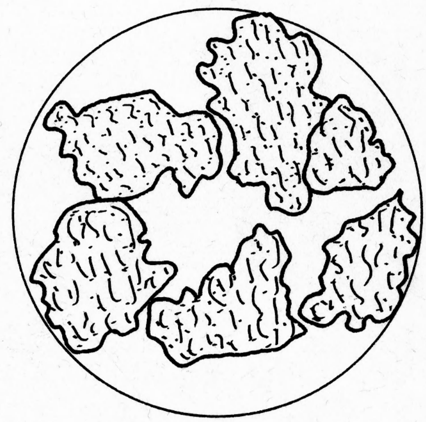

Fig. 6

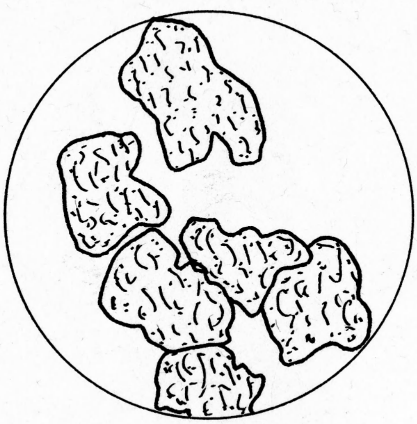

Fig. 7

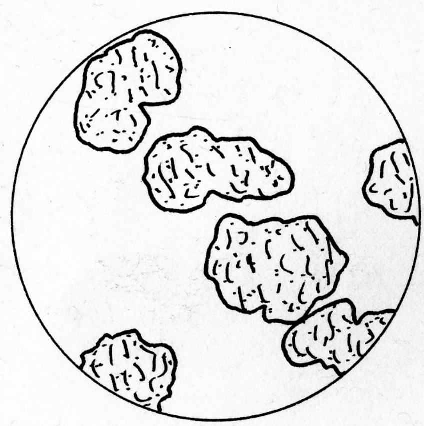

Fig. 8

EXPLANATION OF PLATE V

Fig. 9. Camera lucida drawing of the warp cross-section of fabric E, (X600).

Fig. 10. Camera lucida drawing of the filling cross-section of fabric E, (X600).

Fig. 11. Camera lucida drawing of the warp cross-section of fabric F, (X600).

Fig. 12. Camera lucida drawing of the filling cross-section of fabric F, (X600).

Plate V

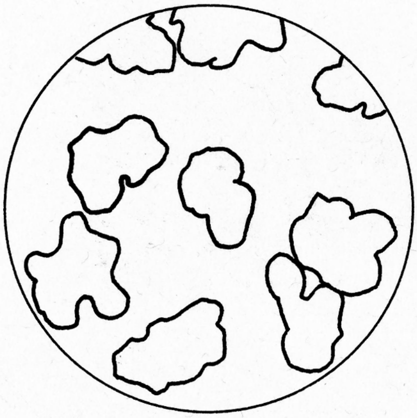

Fig. 9

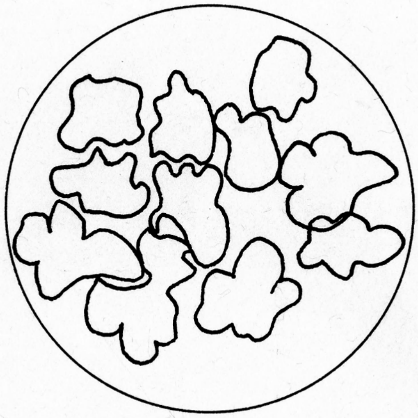

Fig. 10

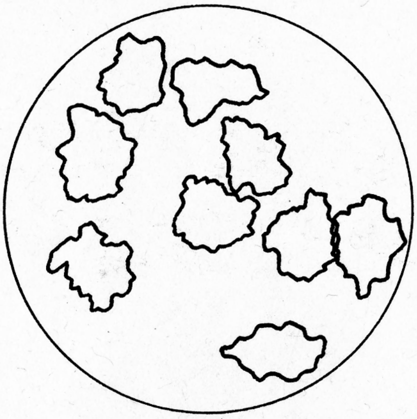

Fig. 11

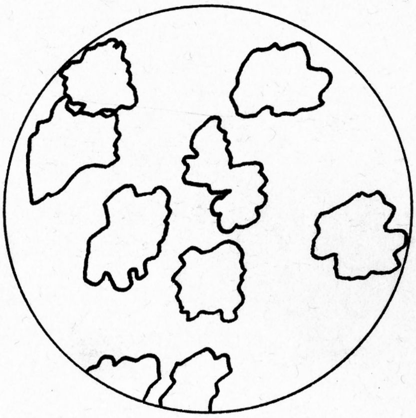

Fig. 12

EXPLANATION OF PLATE VI

Fig. 13. Camera lucida drawing of the warp cross-section of fabric G, (X600).

Fig. 14. Camera lucida drawing of the filling cross-section of fabric G, (X600).

Fig. 15. Camera lucida drawing of the warp cross-section of fabric H, (X600).

Fig. 16. Camera lucida drawing of the filling cross-section of fabric H, (X600).

Plate VI

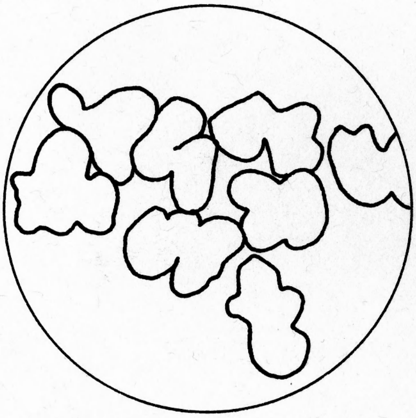

Fig. 13

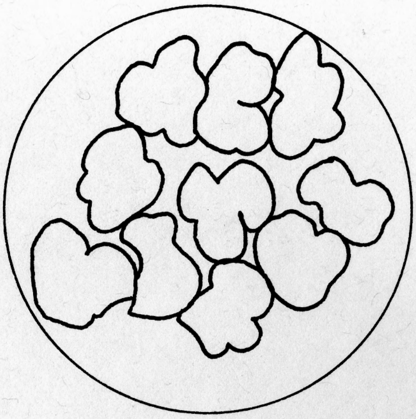

Fig. 14

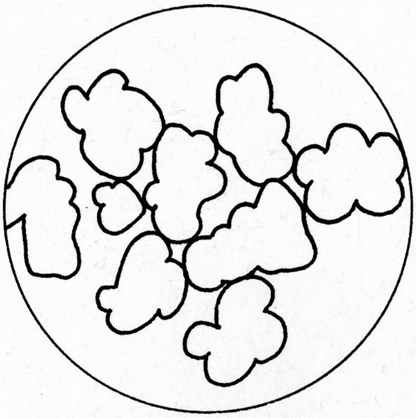

Fig. 15

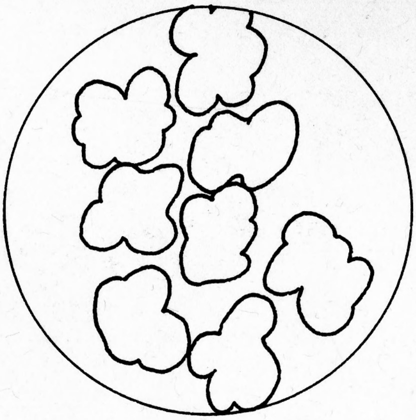

Fig. 16

EXPLANATION OF PLATE VII

Fig. 17. Camera lucida drawing of the warp cross-section of fabric I, (X600).

Fig. 18. Camera lucida drawing of the filling cross-section of fabric I, (X600).

Fig. 19. Camera lucida drawing of the warp cross-section of fabric J, (X600).

Fig. 20. Camera lucida drawing of the filling cross-section of fabric J, (X600).

Plate VII

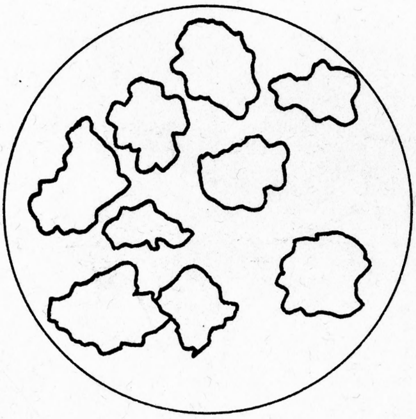

Fig. 17

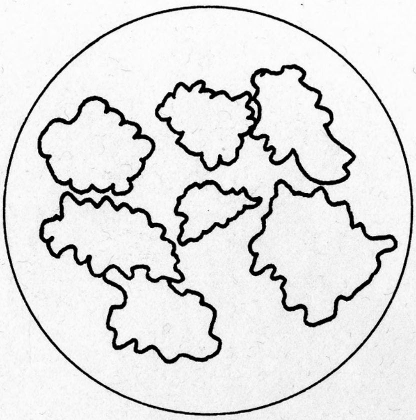

Fig. 18

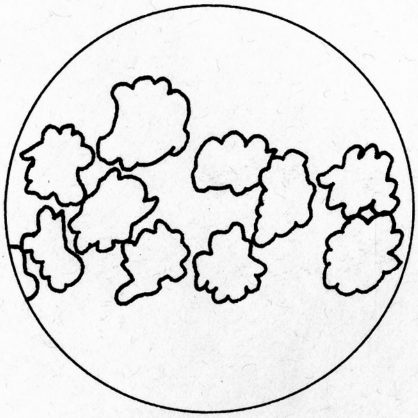

Fig. 19

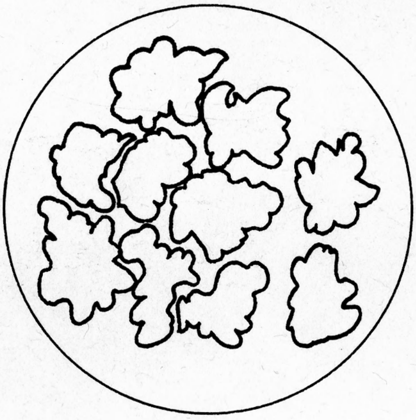

Fig. 20

EXPLANATION OF PLATE VIII

Fig. 21. Camera lucida drawing of the warp cross-section of fabric K, (X600).

Fig. 22. Camera lucida drawing of the filling cross-section of fabric K, (X600).

Fig. 23. Camera lucida drawing of the warp cross-section of fabric L, (X600).

Fig. 24. Camera lucida drawing of the filling cross-section of fabric L, (X600).

Plate VIII

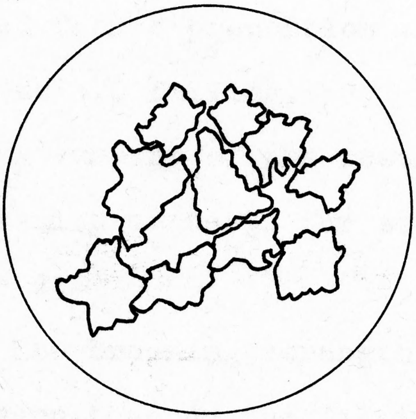

Fig. 21

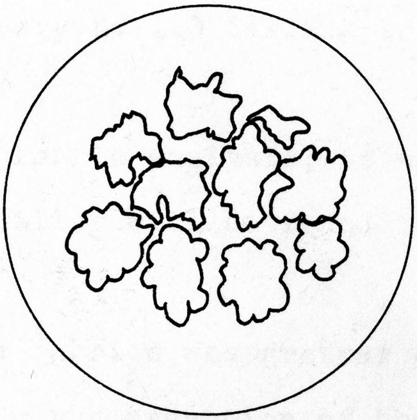

Fig. 22

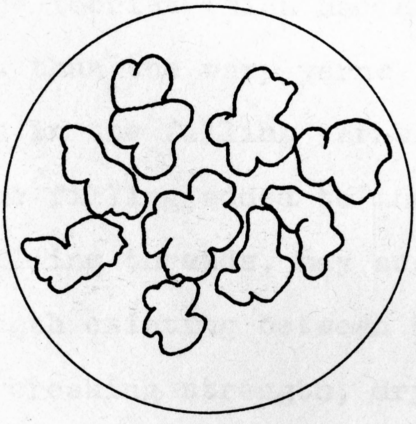

Fig. 23

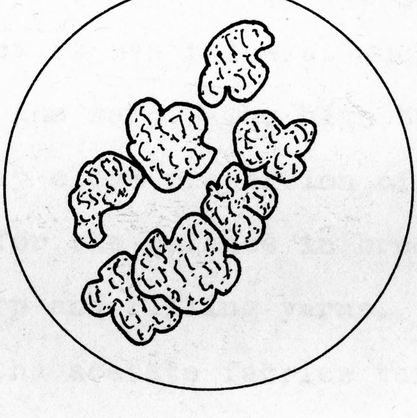

Fig. 24

the proportion of 3.0 warp threads to 1.0 filling to 1.6 warp to 1.0 filling. The crepes showed a proportion of 1.5 warp yarns to 1.0 filling. The thread count of the satins ranged from a proportion of 3.5 warp to 1.0 filling to 1.0 warp to 1.0 filling.

A summary of the results of fabric analysis, as well as results of tests for serviceability will be found in Table 2.

The breaking strength of the fabrics was greater on the warp than on the filling, with the exception of the crepe viscose which had the same breaking strength warpwise and fillingwise. This crepe viscose was the only one of the fabrics which had a higher twist in the filling yarns than the warp yarns, in fact it had twice as much twist in the filling yarns as in the warp. The high twist of the filling added to the fairly close proportion of warp to filling threads, may account for the balance in breaking strength existing between the warp and filling yarns. The warp breaking strength, dry, of the acetate fabrics varied from 62 to 32 pounds, with an average of 53 pounds; the filling varied from 34 to 10 pounds, with an average of 26 pounds. The warp breaking strength, dry, of the viscose fabrics varied from 102 to 47 pounds, with an average of 69

Table 2. A summary of the results of fabric analysis and tests of serviceability.

Fabric	Thread count dry		Twist per inch		Percentage of sizing finishing materials	Resistance to yarn slippage in pounds		Breaking strength				Bias breaking strength		Shrinkage in inches per yard	
								dry		wet					
	W*	F**	W	F		dry	wet	W	F	W	F	dry	wet	W	F
A. Faille taffeta, acetate	115	50	2.7	2.6	0.50	16	15	62	30	31	18	35	24	.60	.75
B. Faille taffeta, viscose	110	50	3.3	2.3	1.00	14	14	84	43	34	16	47	21	2.62	.60
C. Crepe, viscose	99	72	2.2	4.4	2.85	27	14	50	50	19	19	62	23	1.80	.30
D. Crepe, acetate	98	67	3.2	2.6	0.40	16	7	32	24	15	10	34	13	.37	.98
E. Satin, acetate	236	68	4.1	3.6	1.30	5	3	54	10	25	3	12	5	.60	.53
F. Satin, viscose	198	68	2.9	2.9	1.30	12	11	102	32	46	16	53	19	1.57	.98
G. Taffeta, acetate	206	68	3.7	3.0	0.60	22	19	48	32	33	20	43	28	.53	.45
H. Taffeta, acetate	185	60	3.5	2.5	0.35	26	21	45	34	30	22	52	29	.90	.37
I. Taffeta, viscose	76	47	2.3	2.4	4.30	6	6	47	27	20	10	30	12	1.40	.53
J. Satin, viscose	142	72	2.1	1.6	0.70	21	16	77	39	32	17	68	28	1.80	.90
K. Satin, viscose	197	79	2.0	2.1	5.20	16	14	53	37	44	19	61	25	2.70	1.35
L. Satin, acetate	203	76	3.4	1.7	1.00	14	14	49	25	38	16	28	25	.45	.22

*W, warp
**F, filling

pounds; the filling varied from 50 to 27 pounds and averaged 36 pounds. Viscose fabrics tended to have greater tensile strength than acetate fabrics.

The fabrics lost strength when wet in amounts varying from 19 to 62 per cent in the warp and 35 to 70 per cent in the filling. Viscose fabrics, wet, tended to have a greater percentage loss in breaking strength in both warp and filling than acetate fabrics. This agrees with Smith's statement (14) that the affinity of acetate yarn for moisture is less than that of silk, viscose, or wool and that it is consequently less sensitive to moisture changes, and its breaking strength while wet is less affected. Table 3 shows the comparison of the breaking strength of the dry fabrics with the wet.

Fabrics cut on the bias showed an increased strength when dry of 9 to 74 per cent over the fillingwise breaking strength of the fabrics. The percentage increase of breaking strength on the bias of dry fabrics was greater for the acetate taffetas and crepe than for the viscose taffetas and crepe. The percentage increase of breaking strength of bias fabric when dry was greater for viscose satins than for acetate satins. These results tend to indicate that the type of fabric construction influenced the

Table 3. Comparison of the breaking strength of the dry and wet fabrics, warp and filling, with the loss in tensile strength of the wet fabrics expressed in pounds and percentage.

Fabric	Warp breaking strength dry	Warp breaking strength wet	Warp Loss in lbs.	Warp Percentage loss	Filling breaking strength dry	Filling breaking strength wet	Filling Loss in lbs.	Filling Percentage loss
A. Faille taffeta, acetate	62	31	31	50	30	18	12	40
B. Faille taffeta, viscose	84	34	50	60	43	16	27	62
C. Crepe, viscose	50	19	31	62	50	19	31	62
D. Crepe, acetate	32	15	17	47	24	10	14	58
E. Satin, acetate	54	25	29	54	10	3	7	70
F. Satin, viscose	102	46	56	55	32	16	16	50
G. Taffeta, acetate	48	33	15	31	32	20	12	38
H. Taffeta, acetate	45	30	15	31	34	22	12	35
I. Taffeta, viscose	47	20	27	57	27	10	17	63
J. Satin, viscose	77	32	45	58	39	17	22	56
K. Satin, viscose	53	44	9	19	37	19	18	48
L. Satin, acetate	49	38	11	22	25	16	9	36

increase of breaking strength to a greater extent than did the fact that the fabric was acetate or viscose. A comparison of the dry breaking strength of the bias samples and the fillingwise samples of the fabrics is given in Table 4.

Bias fabrics when wet have an increased breaking strength of 19 to 67 per cent over the breaking strength of the fabrics cut fillingwise. The percentage increase of breaking strength of bias fabrics when wet was greater for all acetate fabrics than for viscose. The results of these comparisons appear in Table 5.

The slippage of the warp on the filling threads was greater than the slippage of the filling on the warp, for all fabrics. Resistance to slippage varied from 6 to 27 pounds when the fabrics were tested dry. It was less when the fabrics were wet with the exception of three fabrics in which the resistance remained the same.

According to Simon (13), if resistance to slippage is less than 10 pounds, trouble is very likely to occur and serviceability is doubtful, while with a resistance of over 20 pounds, there is little possibility of any reason for complaint. The fabrics were judged according to this standard. Two of the acetate taffetas, tested both dry and

Table 4. Comparison of the dry breaking strength of the bias samples and the dry breaking strength of the samples in their weakest thread expressed in pounds and in percentage increase.

Fabric	Warp	Filling	Bias	Difference in pounds between the bias breaking strength and that of the filling	Percentage increase of bias breaking strength over that of the filling
A. Faille taffeta, acetate	62	30	35	5	17
B. Faille taffeta, viscose	84	43	47	4	9
C. Crepe, viscose	50	50	62	12	19
D. Crepe, acetate	32	24	34	10	42
E. Satin, acetate	54	10	12	2	20
F. Satin, viscose	102	32	53	21	66
G. Taffeta, acetate	48	32	43	11	34
H. Taffeta, acetate	45	34	52	18	53
I. Taffeta, viscose	47	27	30	3	11
J. Satin, viscose	77	39	68	29	74
K. Satin, viscose	53	37	61	24	65
L. Satin, acetate	49	25	28	3	12

Table 5. Comparison of the wet breaking strength of the bias samples with the wet breaking strength of the fabric in their weakest thread expressed in pounds and in percentage increase.

Fabric	Warp	Filling	Bias	Difference in pounds between the bias breaking strength and that of the filling	Percentage increase of bias breaking strength over that of the filling
A. Faille taffeta, acetate	31	18	24	6	33
B. Faille taffeta, viscose	34	16	21	5	31
C. Crepe, viscose	19	19	23	4	21
D. Crepe, acetate	15	10	13	3	30
E. Satin, acetate	25	3	5	2	67
F. Satin, viscose	46	16	19	3	19
G. Taffeta, acetate	33	20	28	8	40
H. Taffeta, acetate	30	22	29	7	32
I. Taffeta, viscose	20	10	12	2	20
J. Satin, viscose	32	17	28	11	65
K. Satin, viscose	44	19	25	6	32
L. Satin, acetate	38	16	25	9	56

wet, showed a high resistance to slippage, and the third, a moderate degree of resistance. One viscose taffeta showed a moderate degree of resistance to slippage both wet and dry, but the second was so low that it withstood only 6 pounds strain. This viscose had a much lower warp thread count than any of the other taffetas. The viscose crepe was highly resistant to slippage when tested dry, but the acetate crepe had only moderate resistance. When tested wet, the viscose crepe was moderately resistant; the acetate crepe withstood only 7 pounds strain. The viscose satins and acetate satins all were moderately resistant to slippage when tested both dry and wet, with the exception of one acetate satin. This showed only 5 pounds resistance when dry and 3 pounds when wet. The resistance to slippage, with a comparison of the resistance dry and wet, is found in Table 6.

The fabrics tested shrank in amounts varying from 1.0 to 7.5 per cent in the warp, and 0.6 to 3.5 per cent in the filling. Viscose fabrics showed a higher percentage of shrinkage on the average than the acetate fabrics. They shrank in percentages varying from 4.6 to 7.5 per cent in the warp as compared to 1.0 to 2.5 per cent in the warp of the acetate fabrics; and in percentages varying from 0.8 to

Table 6. The resistance of fabrics to yarn slippage, dry and wet, with the change when wet expressed in pounds and in percentage of the resistance to slippage when dry.

Fabric	Dry	Wet	Pounds loss in resistance	Percentage loss in resistance
A. Faille taffeta, acetate	16	15	1	6.2
B. Faille taffeta, viscose	14	14	0	0.0
C. Crepe, viscose	27	14	13	48.0
D. Crepe, acetate	16	7	9	56.0
E. Satin, acetate	5	3	2	40.0
F. Satin, viscose	12	11	1	8.3
G. Taffeta, acetate	22	19	3	14.0
H. Taffeta, acetate	26	21	5	19.0
I. Taffeta, viscose	6	6	0	0.0
J. Satin, viscose	21	16	5	24.0
K. Satin, viscose	16	14	2	13.0
L. Satin, acetate	14	14	0	0.0

3.5 per cent in the filling as compared to 0.6 to 2.7 per cent in the filling of the acetate fabrics. Table 7 presents these data.

CONCLUSIONS

From the limited amount of data acquired in this study, it would seem that the high count acetate taffetas are the most durable rayon fabrics for women's service garments.

These fabrics were satisfactory in breaking strength although not so high as satins, and a fair degree of balance existed between warp and filling strength. Acetate taffetas were superior in their ability to withstand the strain that produces slippage, and were among those fabrics that shrank but little. The qualities of durability possessed by rayon taffetas may be offset in part by the fact that they are so closely woven that they prevent the passage of air. They may retain body heat and for this reason be undesirable for certain uses.

Data concerning resistance to abrasion would give valuable information concerning the ability of the fabrics to withstand conditions of actual wear. Such information should be secured before final conclusions are drawn.

Table 7. Shrinkage of fabrics as expressed in inches per yard and as a percentage loss of the dimension before laundering.

Fabrics	Shrinkage in inches per yard		Percentage loss of the dimension before laundering	
	Warp	Filling	Warp	Filling
A. Faille taffeta, acetate	0.60	0.75	1.7	2.1
B. Faille taffeta, viscose	2.62	0.60	7.3	1.7
C. Crepe, viscose	1.80	0.30	5.0	0.8
D. Crepe, acetate	0.37	0.98	1.0	2.7
E. Satin, acetate	0.60	0.53	1.7	1.5
F. Satin, viscose	1.57	0.98	4.6	2.7
G. Taffeta, acetate	0.53	0.45	1.5	1.3
H. Taffeta, acetate	0.90	0.37	2.5	1.0
I. Taffeta, viscose	1.40	0.53	4.0	1.5
J. Satin, viscose	1.80	0.90	5.0	2.5
K. Satin, viscose	2.70	1.35	7.5	3.5
L. Satin, acetate	0.45	0.22	1.3	0.6

ACKNOWLEDGMENT

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