THE WEARING QUALITIES OF CERTAIN READY-MADE GARMENTS

by

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INTRODUCTION

Dissatisfaction is expressed by many consumers concerning the wear received from ready-made slips sold as silk. It is thought that satisfaction is dependent in part upon the character of the fabric as influenced by fiber content, fabric construction, and amount of weighting. It is also thought that the construction of the garment and the wear given by different individuals affects the satisfaction which may be realized. Little information is available to support these assumptions.

The purpose of this study was to ascertain the character of fabrics found in certain slips sold as silk; to ascertain the durability of these various fabrics, as shown by the combined effect of wear, laundering, and aging; and to study the effect of wear given by different individuals upon slips of similar design and quality.

STATUS OF KNOWLEDGE IN THE FIELD

Garments made either in part or entirely of silk have become universally worn. There seems to be a great need for studies concerning the wearing qualities of such garments. Some studies have been reported concerning the performance of the fabric under certain physical and chemical tests. A few studies have been reported on the wearing qualities of garments made of silk.

Factors Affecting Service Qualities of Silk Fabrics

A number of investigators report findings concerning silk fabrics which have been subjected to laboratory tests. These studies include the effect of perspiration and aging on weighted and unweighted silks, the effect of weighting on air permeability, the effect of storage in the dark on breaking strength and the effect of cleaning on silk fabrics. A review of these reports follows:

Mack and Cooke (1931) studied the effect of perspirations and of aging on silk dress materials. Fifty ready-made silk dresses were purchased at retail in the spring of 1930. The dresses ranged in price from $2.98 to $59.50. The study shows that 47 of the 50 clerks misrepresented to the purchaser the amount of weighting present in the fabrics. In some cases store buyers were consulted, and they failed to give correct information. Silks of only 3 of the dresses contained no mineral weighting. Of the remaining 47, 1 was 100 per cent rayon; and 44 contained approximately 50 per cent or more of the tin-phosphate weighting. Only 2 of the dresses had a breaking strength of more than 20 pounds, an amount generally conceded to be the very minimum of safety in the weaker direction of the fabric.

According to these investigators, the results of the tests showed that the silk fabric which was stored in the dark but not in vacuum for one year had almost no loss in breaking strength, likewise those fabrics stored in the dark and vacuum lost very little of their tensile strength. Exposure of the fabric to indoor light was found to render most of the weighted silks unusuable after 4 months of exposure, while the unweighted fabrics showed but small loss of strength. Those treated with perspiration then exposed to indoor light for 4 months suffered severe damage; many could be pulled apart with the hands when only a slight exertion was applied. None of the weighted silks were usable, except the one with only 13 per cent weighting. The unweighted silks showed some loss but none were close to the danger mark. Fifty-eight per cent of the fabrics spotted with water. Laundering did not cause much loss in strength; but caused great shrinkage, especially in the heavily weighted silks. Dry cleaning caused almost no loss of strength in any of the fabrics. Regardless of price, the majority of the fabrics showed serious loss of color during laundering, application of perspiration, and exposure to indoor light. When the behavior of the fabrics was compared to the statement of the clerks at the time of purchase, as to how they would behave, there was found to be no correlation whatsoever.

Roberts and Mack (1932) made a study of the effect of artificial perspiration on the breaking strength of weighted and unweighted silks. They used samples of silk which were especially dressed and weighted for the study. Solutions of artificial perspiration, both acid and alkaline, were prepared according to the formulas of the American Society of Textile Chemists and Colorists. The study shows that there is considerable difference in results when perspiration is applied to new fabrics than when it is applied to fabrics previously exposed to air and indoor light. The study indicates that, if studies on the relative effects of perspiration on silks subjected to different commercial processes are to be of any value, they must take into account the effect of the perspiration combined with those of the aging influences to which the silk may be subjected in actual wear.

Ross and Edgar (1935) made a study of the cleaning of weighted silk fabrics. They studied materials containing no weighting; also some containing tin weighting, lead weighting, tin-lead weighting, and zinc weighting. A portion of each fabric was dry cleaned and laundered 33 times, at the end of which period some of the weighted fabrics began to split. They were then analyzed for weighting, for wet and dry breaking strength, and for elongation at the breaking load. The analysis shows the fabric to fail very differently in breaking strength upon cleaning. The average loss in dry breaking strength of the fabric after 33 dry cleanings were: iron weighted fabrics, 40 per cent; lead weighted fabrics, 12 per cent; tin weighted fabrics, 52 per cent; tin-lead weighted fabrics, 53 per cent; zinc weighted fabrics, 18 per cent; and degummed fabrics, 18 per cent. The average loss in dry breaking strength after 33 launderings were: iron weighted fabrics, 32 per cent; lead weighted fabrics, 35 per cent; tin weighted fabrics, 19 per cent; tin-lead weighted fabrics, 47 per cent; zinc weighted fabrics, 32 per cent; and degummed fabrics, 38 per cent. The study shows that the silk fabrics weighted with salts of different metals were found to react very differently upon cleaning. The losses of strength brought about by dry cleaning and by laundering were different. The tin weighted and the tin-lead weighted silks were weakened much more by dry cleaning than by laundering. The elasticity of the dry weighted silks was lowered a great deal by dry cleaning. Of the 5 weighted silks, the tin-lead weighted silk was most weakened by cleaning and the zinc weighted silk withstood cleaning the most satisfactorily.

Appel and Jessup (1935) gave an accelerated aging test for weighted silk. They state that the rate at which silk, particularly weighted silk, will deteriorate on exposure to light, heat, and moist air cannot be predicted simply from the amount of weighting or other substances present on the silk. A laboratory test which will indicate the relative stability of silk is needed. The aging as revealed by changes in breaking strength of a variety of silk and weighted silk cloths was studied. Silks were stored in the dark, then exposed to daylight received through a north window, or to the radiation from a carbon-arc lamp under controlled conditions. It was found that silk deteriorates when exposed to daylight, becoming weak and brittle. The rate of deterioration depends not only upon the nature of the radiation and of the atmosphere about the silk, but also upon the substances present upon it. Sizing, weighting, and finishing materials and even traces of acids, alkalies, salts, soaps, and oils left on the silk after processing, dry cleaning or laundering may influence the rate of deterioration materially. Some of the substances increased the rate, others decreased it. Therefore the extent of the deterioration to be expected in a given time cannot be predicted simply from the amount of weighting or other substances present on the silk. The effect of aging was determined by changes in the breaking strength of silk. Silk stored in the dark showed none of the fabrics decreased in strength more than 20 per cent when aged for 24 days. The strength of the more heavily weighted silks did not change more than that of the silks containing less weighting or no weighting. The decrease in strength on exposure to light for 240 days varied from a little over 20 per cent to 95 per cent, depending upon the finishing treatment the silk had received. There was no consistent relationship between the decrease in breaking strength of the fabric studied and the amount of non-fibrous materials in them.

Cohen and Mack (1929) studied the effect of home laundry methods upon the breaking strength of unweighted and weighted silk. The samples, consisting of one yard pieces of silks, contained various weightings and finishings. Different types of laundry methods, soaps, water, and the like were used. The study shows that washing with a disc type washing machine produced the least tendering effect except in the case of the most heavily weighted pieces when it fell to fourth place. In general washing between cupped hands ranked second and washing on the board ranked third, while rubbing between knuckles has the greatest tendering effect on all samples, except those most heavily weighted.

Cormany (1932) studied the effect of ultra-violet radiation and perspiration on the breaking strength of certain silk fabrics. Specimens of specially prepared silks containing known percentages of weighting were subjected to tests under a standard Luxor model alpine sun lamp, and to human perspiration. Cormany found that white specimens became yellow when exposed to ultra-violet radiation or saturated with perspiration, and therefore assumed that oxidation took place. Perspiration seemed to have a greater effect on the breaking strength of the specimens than ultra-violet radiation alone. Ultra-violet radiation and perspiration have a tendering effect upon silks. Silk fabrics, saturated with perspiration and exposed to ultra-violet radiation while moist, are tendered more than when saturated with perspiration and allowed to dry before exposure to ultra-violet rays. A small amount of weighting does not seem to increase the rapidity with which silk fabrics lose strength when treated. Short exposure to ultra-violet radiation with a time interval between exposures cause greater tendering of the silk than one long exposure. Repeated saturations with perspirations increase the rate of tendering of the silks.

Southard (1930) studied the effect of perspiration on the breaking strength of selected silk fabrics. The silk fabrics were subjected to saturations of human perspiration and aged for 15 days at different temperatures. It was found that aging with perspiration causes a decrease in the breaking strength of the weighted silk fabrics used and that the decrease is greater when a higher temperature is maintained.

Bruner and Goehring (1935) reported on the deterioration of silks by light of different wave lengths. X-ray diffraction patterns of solutions of the silk fabrics were made. They found that lead weighted silk gave a typical powder pattern; 50 per cent tin-weighted silk gave slight evidence of fibering; 43 per cent tin-weighted gave a much stronger fiber pattern. Diagrams of the unweighted silk before exposure to the light source, and after exposure to the entire spectrum appeared similar but photometric analysis indicated that exposure of silk to light results in a decrease in fiber orientation causing the long fiber arc to expand to the character of the powder pattern.

Wearing Qualities of Ready-Made Garments

Some studies have been reported on the wearing qualities of ready-made garments made of silk. A review of such studies as were available follows.

Laramy (1932 - 1933) analyzed silk slips for weighting content and for durability as part of a project in an under-graduate course in Textile Chemistry. The work was continued during 1933-1934 by Mack until 20 silk slips, ranging in price from $1.75 to $4.95, had been purchased and tested. The following facts were revealed by the study:

None of the garments was sold as being made of weighted silk although 13 of the 20 were shown on analysis to be weighted heavily. Two were shown to have small amounts of weighting and only 5 were found to be of pure dye silk. The oral sales information was inaccurate in 8 of the 9 cases. The information on the labels was misleading in 3 of the 5 cases. When labels reading "pure dye" were attached to the slips, the fabrics were found to be in conformity with the Federal Trade Commission definition of this term. The other labels carried the designations, "All Silk", or "Pure Silk", terms which are without standard meaning and which are misleading when attached to fabrics containing but 30 to 40 per cent of silk fibroin, the remainder weighting. The greater the amount of mineral weighting in the fabric, the poorer the fabric performed in the durability tests. No correlation was seen between the price of the slips and the weighting content or durability of the fabrics.

Whitlock (1936) made a study of 8 pieces of silk materials which were made into 20 dresses. Two silks were pure dye, 1 of these being a spun silk, and 6 silks were weighted. All except the spun silk were flat crepes. The dresses were given to individuals for the purpose of testing actual wear received from the garment. The wearing records showed that the number of hours wear varied from 90 to 789 hours, that the number of times worn ranged from 14 to 197, and the number of years the dresses were under a durability test ranged from 1 to 4 years. The dresses were cleaned from 1 to 16 times. The ratio between the number of cleanings and hours wear ranged from 1:30 to 1:226 hours. The dresses were turned in when they showed evidence of wear. All the silks tested poor or very poor in fastness to light, 2 of the dresses shrank, 10 of the dresses were injured by perspiration in color or strength. The silks in this study, for the most part, gave evidence of the same difficulties to the different cooperators, whether they were hard or easy on their clothes. If fading, running colors, yarn slippage, or water spotting was a problem in 1 dress, it was a problem in all the dresses made from the same silk. The experiment points to many problems needing intensive study.

Keeney and Fulton (1932) made a study of silk dress fabrics as a basis for the selection of a silk fabric for girls' uniforms. Stores were visited to obtain samples of fabrics of suitable color, weight, and price. Pieces of the fabric deemed suitable on the basis of superficial appearance and price were given laboratory determinations of percentages of weighting, breaking strength before and after aging, resistance to abrasion, and dry-cleanability.

On the basis of the analyses, a fabric was selected which was believed to be the most durable, and information concerning where this could be purchased was made available to students. The result of this study showed that if the Federal Trade Commission definition of pure dye silk were applied, 8 pieces of silk (26.6 per cent of the total) were accurately described as to weighting content, 5 pieces (16.6 per cent of the total) were not described at all or were given vague or only partially accurate descriptions, and 17 (56.6 per cent of the total) were described inaccurately. The study further showed that there was a wide variation in the accuracy of the descriptions given by the various stores from which samples were obtained.

METHOD OF PROCEDURE

Six groups each consisting of 5 bias silk slips of 6 different qualities or made by different companies were obtained. The retail prices of these groups were distributed as follows: 1, $3.00; 1, $1.95; 1, $1.89; 1, $1.69; and 2, $1.00. Figures 1 to 6 show the construction of the garments used. The direction of the warp yarns in each part of the garment has been indicated. In figure 7, samples of the materials used in each of the 6 groups are presented. One of each group was designated as the control, the other four were subjected to wear. Among the 24 slips used in the wear test, the following distribution of sizes was required by the subjects: 4 32's, 9 34's, 9 36's and 2 38's. Each of the 6 groups of slips has been referred to by letters from A to F, inclusive. Individual slips within the group subjected to wear have been referred to by number from 1 to 4 for each of the letter groups. For example, 1 group of slips consists of A1, A2, A3, and A4.

Thread count and thickness of fabric of each slip was used to determine the similarity of the slips comprising the group. Results of tests showed only such variation as might have existed within the fabric of each garment. It was therefore assumed that like fabric was used to construct slips comprising a group. Data concerning the analysis of the fabric appear in table 4.

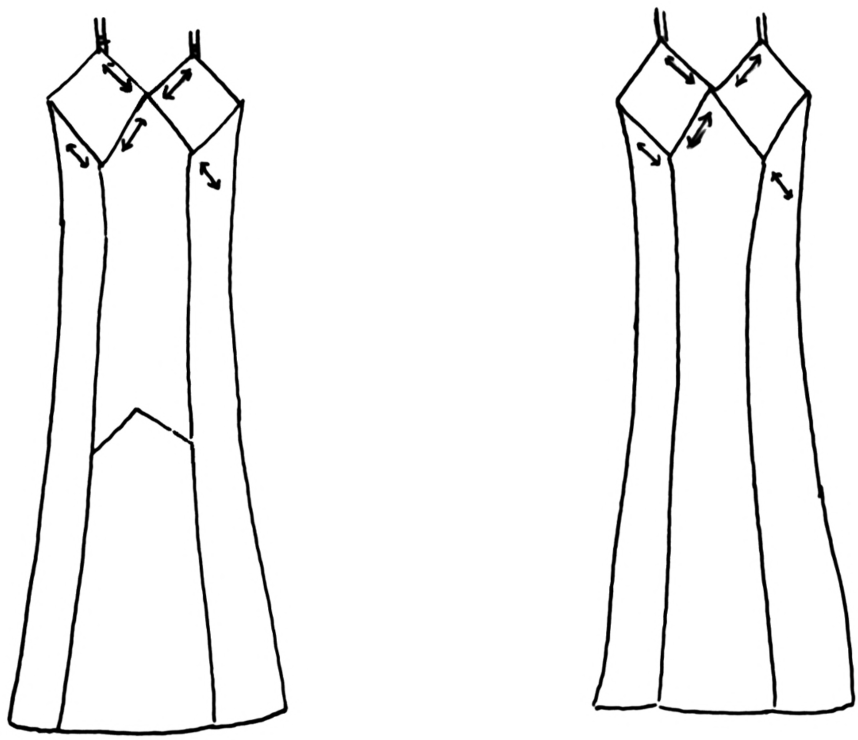
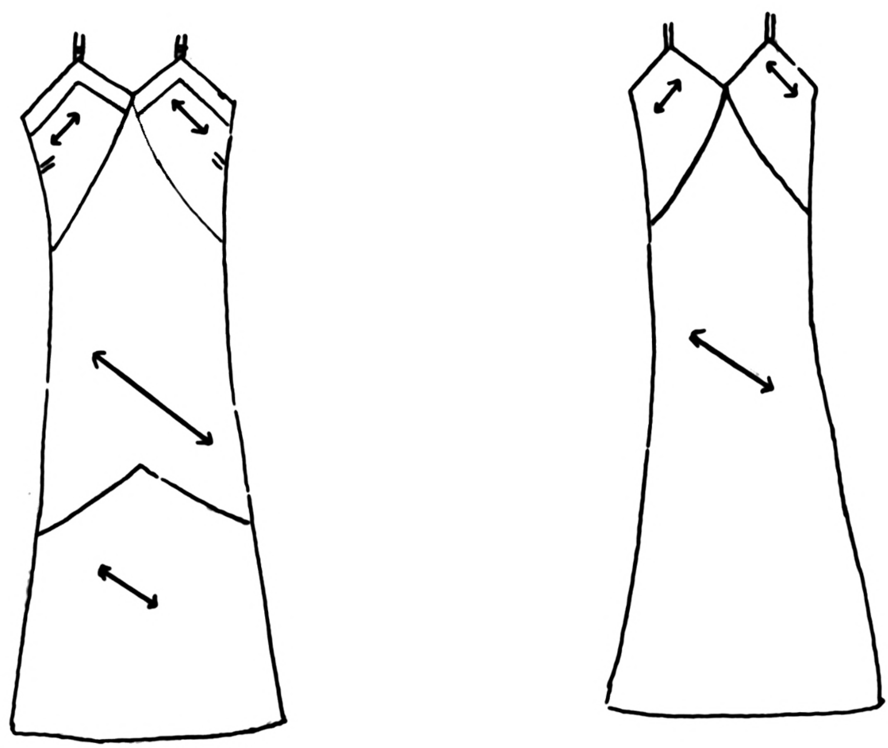


Figure 1. Diagram showing construction of slip A. The arrows indicate direction of warp yarns of the material.



Front Back

Figure 2. Diagram showing construction of slip B. The arrows indicate direction of warp yarns of the material.

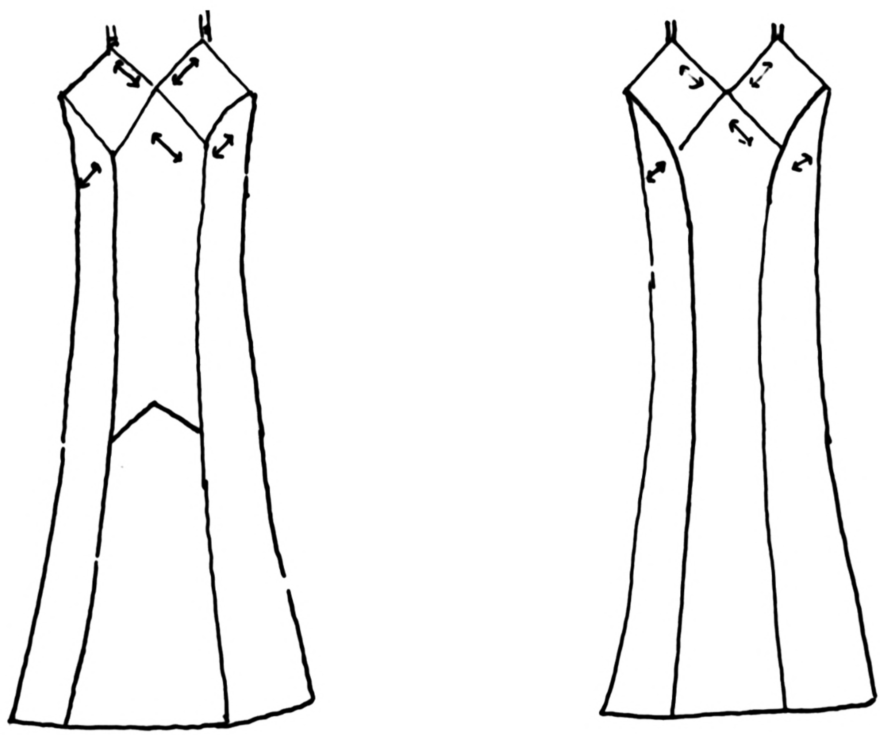


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Figure 3. Diagram showing construction of slip C. The arrows indicate direction of warp yarns of the material.

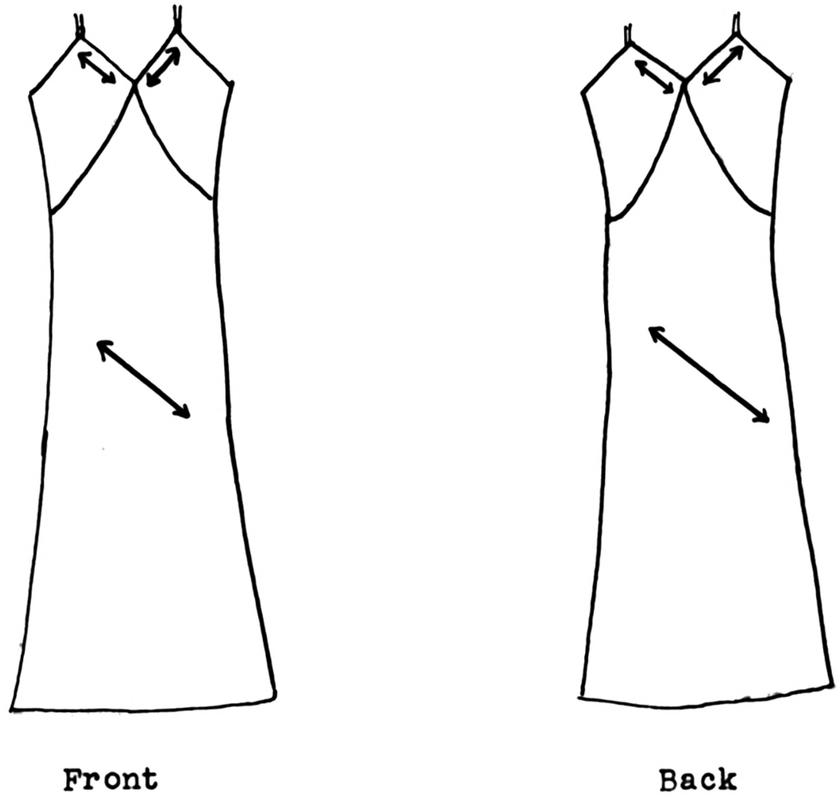

Figure 4. Diagram showing construction of slip D. The arrows indicate direction of warp yarns of the material.

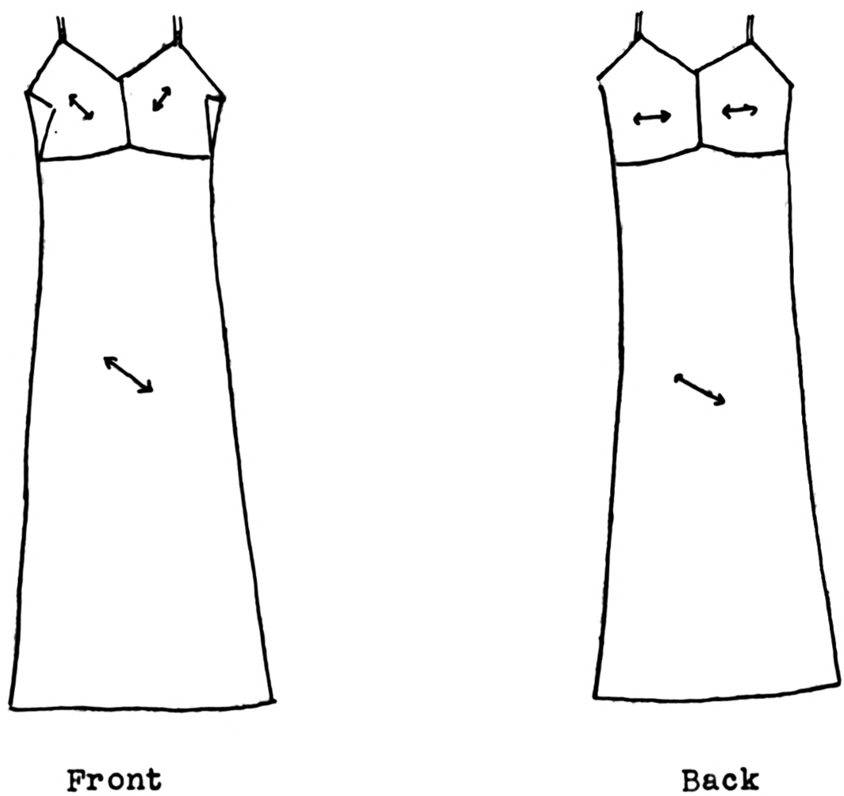

Figure 5. Diagram showing construction of slip E. The arrows indicate direction of warp yarns of the material.

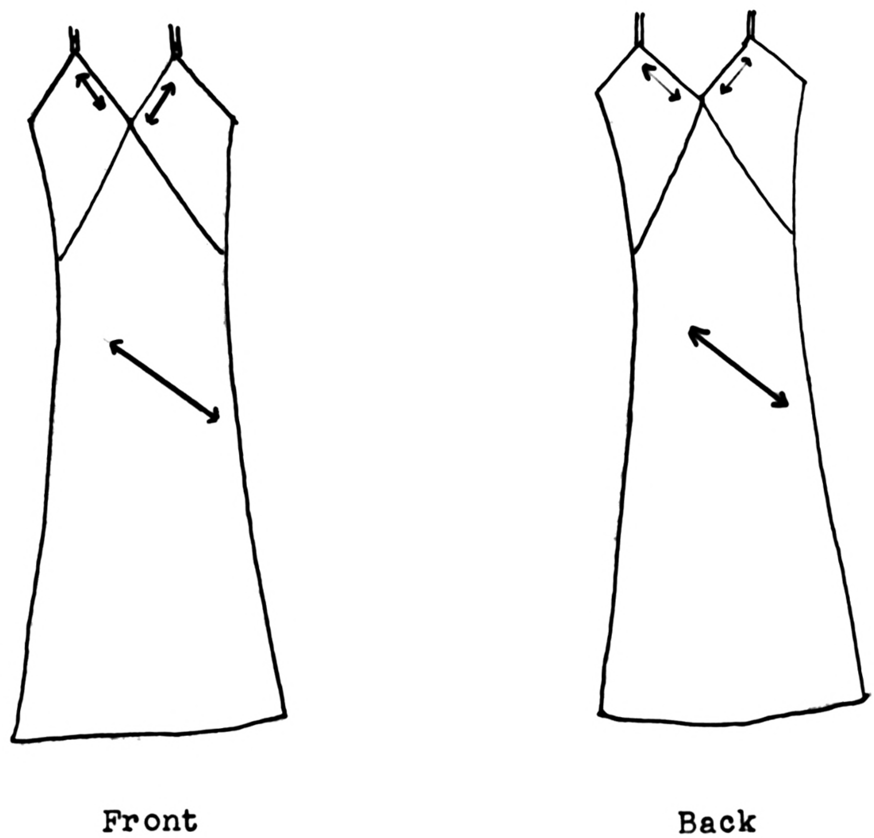

Figure 6. Diagram showing construction of slip F. The arrows indicate direction of warp yarns of the material.

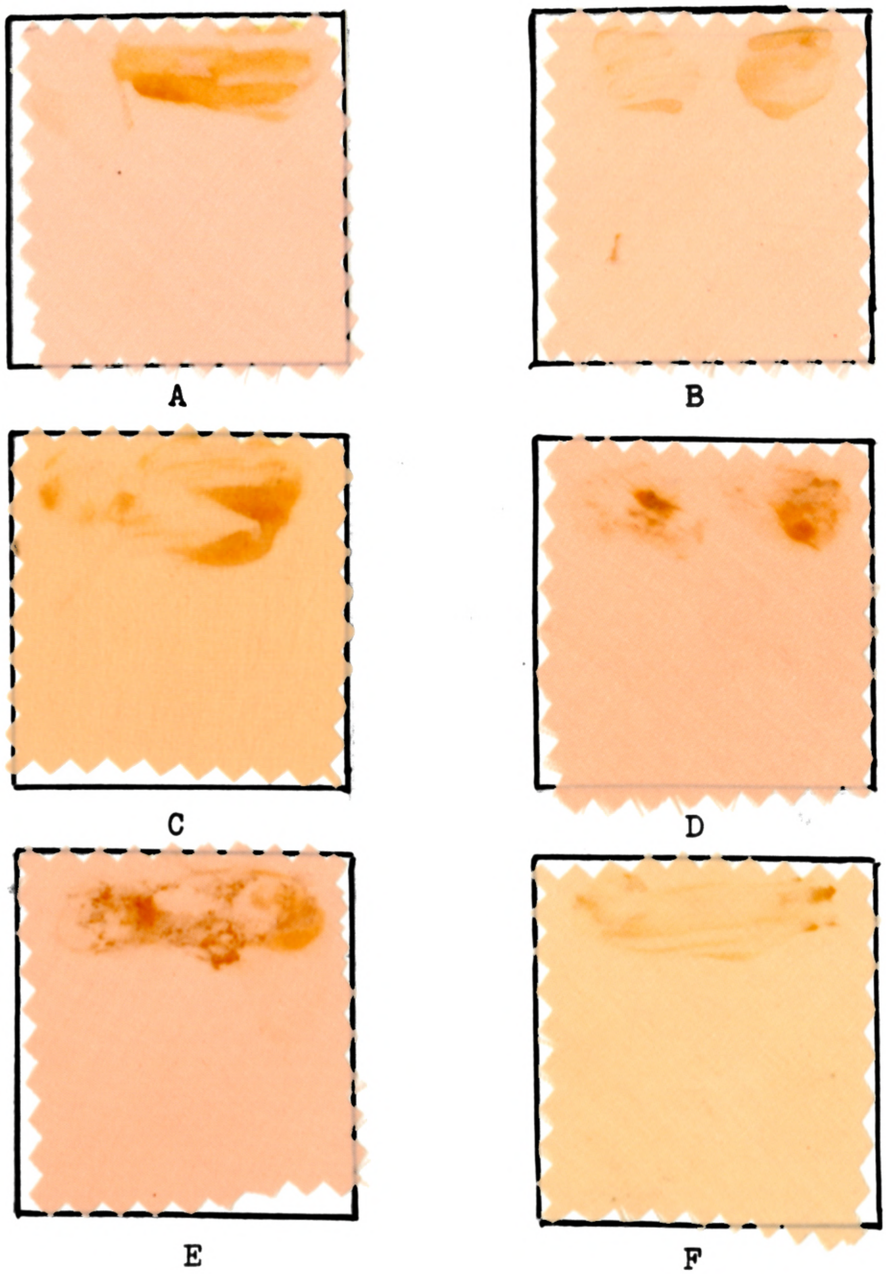

Figure 7. Samples of material of the 6 groups of slips.

Serviceability Records

The 4 slips of each group designated for service were worn by adults engaged in business or professional occupations. The time of year during which they were worn was from September through May. At the end of a period of 525 hours the slips were checked. All 4 of 2 groups were retired from service because they showed excessive wear. Of the 3 groups showing little wear, 2 were withdrawn from service and 2 continued in service for 475 additional hours.

Each wearer received instructions for laundering and care of the slips. A chart was included for recording the number of times the slip was worn, the number of hours worn each day, and the number of times laundered. At the end of the period of wear, the charts for recording wear were tabulated and summarized. Data were obtained concerning the habits of the wearer as to the type of work engaged in, other habits that would affect the service of the slip, and whether the wearer thought she was hard or easy on her clothing. These data were also summarized. Copies of the chart for recording wear and laundry and also of the questionnaire for obtaining data concerning the habits of the wearer will be found in the appendix.

At the end of the period of service each slip was inspected and the effect of wear, laundering, and aging noted. Tensile strength and elongation of each fabric was determined to ascertain the effect of wear and laundry. Likewise, at the end of the period of study a portion of the fabric of the control was analyzed for tensile strength and elongation to determine the effect of aging.

Fabric Analysis

A portion of the fabric of the control was analyzed at the beginning of the study. Tests as presented in bulletin D-13 of the American Society for Testing Materials were made for thread count, breaking strength, thickness, twist of yarn, and weight per square yard.

Yarn slippage was determined by holding the material in the cupped hands, grasping it between the middle fingers and the thumbs. The knuckles of the thumbs were pressed together, acting as a lever, and a pull was exerted on the material by forcing apart the ends of the thumbs.

The test given by Jackman and Rogers (1934) was used to determine the fiber content of the materials. Two pieces of the fabric, each weighing about 5 grams, from each of the control slips were prepared. One specimen is used as a check against the other. The test samples were placed in an alkaline solution of copper and glycerine made by mixing 5 grams of glycerine with 100 cc. of a 10 per cent solution of copper sulphate and adding just a sufficient amount of a strong solution of caustic soda to redissolve the precipitate formed. The fabrics were allowed to remain in the solution for half an hour and were stirred occasionally. The residue was filtered out and dried to constant weight.

The test to determine the effect of synthetic perspiration was an adaptation of one devised by Mack and Cooke. Breaking strength samples were prepared as for the strip method. One set of these samples was submerged in alkaline perspiration and one in acid perspiration for 5 minutes, removed and allowed to dry on a flat surface under standard conditions. After 10 hours, they were broken. Similar sets were saturated 2, 3, 4, and 5 times and then broken. The samples remained in the solution 5 minutes each time and 24 hours elapsed between each saturation. The following formulae for perspiration were used:

Acid Perspiration

2½ grams sodium chloride

¼ gram U. S. P. lactic acid

¼ gram monosodium orthophosphate dissolved in sufficient distilled water to make one liter of solution

Alkaline Perspiration

2½ grams sodium chloride

1 gram U. S. P. ammonium carbonate

¼ gram disodium orthophosphate dissolved in sufficient distilled water to make one liter of solution

The above formulae are ¼ the strength of those used by Mack and Cooke (1931). To determine the strength of perspiration solutions comparable with human perspiration, silks of known weighting were treated with solutions of varying strengths. It was found that synthetic perspiration ¼ the strength of that used by the above authors gave results most comparable with those reported by Cormany (1932) on the effect of human perspiration on breaking strength of silk fabric.

The kind and amount of water soluble weighting was determined by the method described by Hillebrand and Lundell (1926). A specimen of about 5 grams weight of each control slip was dried to constant weight. The dry sample was extracted with carbon tetrachloride to remove any oils present. It was again dried to constant weight. The specimen was then boiled in 20 times its weight of distilled water for ½ hour, water was added to make up for evaporation. The boiling was repeated twice more and the extract poured off and saved for further analysis. The sample was then rinsed in boiling water until the rinsings were clear. The sample was again dried to constant weight.

A test for dextrin was made by placing a piece of about 3 grams weight of each control slip in about 20 times its weight of distilled water at about 20 degrees C. for about 30 minutes, stirring frequently. The solution was then filtered and the filtrate tested for dextrin by adding a few drops of dilute iodine solution. A red-brown coloration would indicate that dextrin was present.

The test for glucose was made by boiling down a portion of the hot water extract in a beaker, transferring it to an evaporating dish, and evaporating it to almost dryness in a steam bath. A few drops of the concentrate was diluted with water, then Fehling's solution was added until the mixture was permanently blue. It was then warmed. A red or yellow precipitate would indicate the presence of glucose.

The solution used in the glucose test was boiled and filtered for the cane sugar test. The filtrate was made acid with dilute sulphuric acid. It was boiled for 10 minutes and diluted to the original volume with distilled water then neutralized with caustic soda. Fehling's solution was added until the mixture was permanently blue, then the solution was boiled for 2 minutes. The formation of a cuprous oxide precipitate would indicate the presence of cane sugar.

Quantitative tests for weighting were determined by methods recommended by Appel (1929). Two four-inch squares of each of the control slips were dried to constant weight. This weight is called weight A. Soluble finishes were removed by the following method: The specimens were immersed for about 2 minutes in each of two 30 ml. portions of diethyl ether at room temperature. They were squeezed by hand after each immersion. Then they were treated similarly with two 30 ml. portions of ethyl alcohol at 50 to 60° C. The specimens were then immersed in 90 to 100 times their weight of distilled water at 65 to 70° C. for

20 minutes, squeezed by hand, rinsed by immersion for about $\frac{1}{2}$ minute each in 3 fresh portions of distilled water at the same temperature. They were then dried to constant weight. The weight of the dry specimens was called Weight B.

$$\frac{\text{Weight A - Weight B x 100}}{\text{Weight A}} = \text{per cent of water soluble finish in the fabric.}$$

The more firmly held weighting and finishing materials were removed by the following series of treatments. The specimen was immersed for 20 minutes in 90 to 100 times its weight of a solution containing 2 per cent of hydrofluoric acid and 2 per cent of hydrochloric acid and maintained at a temperature of 55° C. The acid liquid was decanted and the specimen rinsed with 2 portions of distilled water at 55 to 60° C., squeezing by hand after each rinsing. The treatment with acid solution followed by rinsing was repeated. The treatment was again repeated using a 2 per cent solution of sodium carbonate in place of the acid solution. The treatment with the acid solution was applied 2 times more, the specimen rinsed as previously described. The specimen was then dried to constant weight. The weight at this time is called Weight C. $\frac{\text{Weight A - Weight C x 100}}{\text{Weight A}}$ = the total weighting expressed as a percentage.

Qualitative tests for weighting were determined by the methods recommended by Preston and Johnson (1925). A piece of material about 4 inches by 10 inches of each control slip was prepared. The fabric was thoroughly wet in a solution containing 90 grams of anhydrous sodium carbonate and 90 grams of anhydrous potassium carbonate dissolved in 400 ml. of distilled water. The sample was then suspended over a beaker containing 30 ml. of about 10 per cent solution of hydrochloric acid and dried by brushing a flame on the lower edge. The fused portions were allowed to drop in the acid in the beaker. The materials were burned until they had completely dropped into the beakers.

The presence of silica was determined by boiling a portion of the above solution. A white flocculent precipitate would indicated the presence of silicates. The solution was then decanted and filtered and the contents of the beaker digested with about 10 ml. of warm concentrated hydrochloric acid for 15 minutes. The acid was poured through a filter paper and added to the filtrate, then boiled with 5 ml. of concentrated nitric acid. It was then cooked and neutralized with a 25 per cent solution of sodium hydroxide and enough hydrochloric acid added to produce a clear solution. The solution was used for the remainder of the tests. For purposes of this report, it is called solution A.

The presence of lead was determined by neutralizing about 3 ml. of solution A with sodium hydroxide, phenolphthalein being used as an indicator. The solution was then made just acid with hydrochloric acid and about 1 ml. of water saturated with hydrogen sulphide added. A gray or black coloration would indicate the presence of lead.

The test for aluminum was made by adding to about 3 ml. of solution A, ½ ml. of a saturated solution of ammonium chloride, ½ ml. of alizarin (prepared by dissolving 0.1 gram of the dry Color Index No. 1034 in distilled water), and an excess of ammonium hydroxide. The mixture was then heated to boiling and an excess of glacial acetic acid added and the mixture diluted. A red flocculent precipitate denoted the presence of aluminum.

The test for tin was made by neutralizing about 2 ml. of solution A with a 25 per cent solution of sodium hydroxide and about 5 drops in excess added. The solution was filtered, the filtrate acidified with hydrochloric acid and a few drops of a 1 per cent water solution of cupferron then added. A white precipitate indicated the presence of tin.

The test for zinc was made by neutralizing 3 ml. of solution A with a 25 per cent solution of sodium hydroxide, then enough hydrochloric acid and water were added to produce a clear solution. One-half ml. of a 2 per cent solution of potassium ferrocyanide was added. A white precipitate would indicate the presence of zinc.

The presence of phosphate was determined by neutralizing about 2 ml. of solution A with sodium hydroxide and the resulting solution acidified with nitric acid. It was then heated and added to an equal volume of hot acid ammonium molybdate. A lemon yellow precipitate indicates phosphates.

There was insufficient material in the control slips to make seam slippage tests of the lengthwise seams. Therefore, specimens for the seam slippage were taken from the lower side seams of one of each group of slips that had been worn 525 hours. Test samples 4 inches wide and 6 inches long were cut across the seam and conditioned before testing. Each specimen was placed in the jaws of a Scott tester in such a manner that the seam was midway between the jaws and tested as for tensile strength. The number of pounds pull exerted before seam slippage occurred was recorded. Similar tests of the control slips were made of the seams that join the skirt to the brassiere top. This seam occurs, in some instances, along the bias cut of the fabric and, in some instances, parallel to warp yarns or to filling yarns.

FINDINGS AND DISCUSSION

A summary of the construction features of the 6 groups of slips appears in table 1. Two groups were 4-gore and 4 were 2-gore. The 2 4-gore groups were higher in price than the 2-gore. Lapped seams were used in the 4 highest priced slips, plain seams in the other 2. Pinked seams were found in all slips. No other attempt was made to finish raw edges. Two groups had seams stitched with "lock stitch", in other instances plain machine stitching was used.

The number of stitches per inch ranged from 10 to 35. The "lock stitch" seams showed 32 and 35 per inch, this greater number occurred because the stitching thread was zig-zagged across the seam. Such stitching provided for great elasticity. In general, more stitches appeared in the bodice of the garment than in the skirt.

Table 1. Cost, how purchased, color, and construction features of the 6 groups of bias silk slips.

Slip no.	Cost	How purchased	Color	No. gores	Seam Kind	Seam Finish	Stitches Kind	Stitches Per inch Skirt	Stitches Per inch Bodice
A	$1.95	retail	peach	4	lapped	pinked	plain	14	13
B	1.69	retail	peach	2	lapped	pinked	lock	32	32
C	3.00	retail	peach	4	lapped	pinked	lock	34	35
D	1.00	retail	peach	2	plain	pinked	plain	12	22
E	1.89	retail	peach	2	lapped	pinked	plain	14	16
F	1.00	retail	peach	2	plain	pinked	plain	10	16

Personal Factor in Service Record

Information concerning persons who wore the slips appears in table 2. Seventy-five per cent of the 24 were teachers. The weight of the wearers ranged from 100 to 160 pounds. A personal estimate given by the wearers indicated that about half believed that they moved quickly and half deliberately. Sixteen of the 24 persons did not drive cars and only 2 of the number drove frequently. Only 2 stated that they engaged in other activities that would decidedly affect the wear of the garments. Three persons claimed that they gave their clothing hard wear. No relation seems to exist between the weight of the wearer and the place on the slip where wear first appeared. Neither is there a relationship between the activities of the wearer and the place showing wear.

Only one person indicated that she perspired freely. The slips were worn during the time of year when such a report might be expected. About one-half of the wearers used a non-perspirant or a deodorant. These preparations did not seem to materially affect the service rendered by slips as indicated either by inspection of the garment or by fabric analysis of worn slips.

Table 2. Information concerning the wearer, her occupation and habits that might affect the wear given each slip.

Slip no.	Occupation	Weight	Movements: Quick	Movements: Deliberate	Activities that affect wear: Drive car	Activities that affect wear: Others	Hard or easy on clothing	Where slip first shows wear	Perspire freely	Use non-perspirant or deodorant
A1	teacher	107	-		occasionally	no	easy	seams at hips	no	no
A2	teacher	130	-		occasionally	mo	easy	top at stitching	no	yes
A3	teacher	140	-		no	active	hard	straps	no	no
A4	librarian	121		-	no	no	easy	under arms	no	no
B1	teacher	110		-	no	no	easy	seat	no	yes
B2	teacher	115	-		no	no	easy	side seams	yes	yes
B3	teacher	154		-	occasionally	no	hard	seams	no	yes
B4	editor	131		-	no	no	easy	seat	no	yes
C1	teacher	130		-	no	no	easy	seat	no	yes
C2	teacher	124	-		frequently	no	easy	left thigh	no	no
C3	teacher	120	-		no	no	easy	knees	no	no
C4	teacher	155		-	no	no	easy	seat	no	no
D1	secretary	100		-	no	no	easy	seat	no	no
D2	research	117	-		no	active	hard	straps	no	no
D3	secretary	130	-		no	no	easy	seat	no	no
D4	nurse	138	-		frequently	no	easy	straps	no	no
E1	teacher	112		-	no	no	easy	seat	no	no
E2	teacher	120		-	occasionally	no	easy	seat	no	yes
E3	teacher	112		-	no	no	easy	seat	no	yes
E4	nurse	120		-	no	no	easy	seat	no	yes
F1	teacher	115	-		no	no	easy	seams, straps	no	yes
F2	teacher	116		-	occasionally	no	easy	seat	no	yes
F3	teacher	160	-		no	no	easy	under arms	no	no
F4	teacher	150		-	occasionally	no	easy	top and seams	no	no

A record of the wear given each slip and of the times each was laundered appears in table 3. An attempt was made to have all slips examined for evidence of wear at the end of 500 hours. When the records were totaled, it was found that a number of persons had worn the slips longer than the designated time. An attempt was therefore made to inspect the slips at the end of 525 hours. In spite of efforts on the part of the investigator to obtain results based upon uniform hours of wear, a number of the wearers turned in records, some less than, some exceeding the time designated.

All of the slips in groups B, D, and F were withdrawn from service at this time. Two of the 4 slips comprising groups A, C, and E were withdrawn and 2 continued in service for 475 additional hours.

Among the slips withdrawn after approximately 500 hours of wear, the number of times worn ranged from 35 to 55. For those worn approximately 1,000 hours, the times worn ranged from 68 to 97. The number of hours wear between launderings for all slips ranged from 20 to 166, the average being 61.

Table 3. Wear and laundry record of the 24 silk slips.

Slip no.	Times worn	Number hours worn: Morning	Afternoon	Evening	Total	Times laundered	Av. no hours between launderings
A1	52	227	227	53	525	10	52
A2	68	335	390	275	1000	18	55
A3	38	214	211	117	542	8	64
A4	97	454	456	128	1038	35	29
B1	42	178	232	168	578	9	64
B2	38	153	219	155	527	13	40
B3	53	235	178	85	500	25	20
B4	55	251	263	177	690	11	62
C1	74	353	423	242	1018	16	53
C2	41	179	190	156	525	9	58
C3	72	322	395	283	1000	26	58
C4	41	174	193	157	525	9	58
D1	38	155	215	155	525	6	87
D2	39	181	206	139	525	13	40
D3	40	170	214	159	543	7	77
D4	48	198	283	169	650	16	46
E1	79	310	480	210	1000	6	166
E2	71	261	407	332	1000	31	32
E3	45	224	208	121	553	10	55
E4	55	220	194	111	525	17	31
F1	44	167	198	160	525	13	44
F2	35	176	210	139	502	5	100
F3	36	164	216	145	525	6	88
F4	41	162	192	145	500	5	100

The serviceability record for the 24 worn slips appears in table 4. Here the performance of each slip under service may be noted.

Table 4. Serviceability record of the 24 worn slips.

Slip no.	First evidence of wear: wearings	First evidence of wear: Where found	Thin spot appears: wearings	Thin spot appears: where found	Hole appears: wearings	Hole appears: where found	Pulled seam appears: wearings	Pulled seam appears: where found	Tear appears: wearings	Tear appears: where found	Strap re-sewed: wearings	Received repair: wearings	Received repair: where	Total hours worn	Launderings: total times	Launderings: Av. no. hrs. between
A1	-	-	-	-	-	-	-	-	-	-	-	-	-	525	10	52
A2	34	back seams	45	top	51	top	51	top	77	top	61	45	top	1000	18	55
A3	35	back seams	-	-	-	-	35	back seams	-	-	-	-	-	542	8	64
A4	66	waist line	66	top	-	-	-	-	-	-	-	-	-	1038	35	29
B1	3	seat	-	-	-	-	18	shadow	-	-	9	9	strap	578	9	64
B2	7	seat	7	seat	18	top	7	shadow	-	-	-	-	-	525	13	44
B3	18	seat	22	seat	-	-	30	hip seam	32	seam	14	4	seam	525	25	20
B4	34	seat	34	seat	55	seat	-	-	-	-	55	55	seat	691	11	62
C1	-	-	-	-	-	-	-	-	-	-	-	-	-	1018	16	53
C2	39	seat	-	-	-	-	-	-	-	-	-	-	-	525	9	58
C3	64	knees	-	-	-	-	-	-	-	-	-	-	-	1000	26	58
C4	-	-	-	-	-	-	-	-	-	-	-	-	-	525	9	58
D1	8	seat	-	-	-	-	-	-	-	-	-	-	-	525	6	10
D2	2	seat	3	seat	24	top	5	top	-	-	-	24	top	525	13	18
D3	4	underarm	13	seat	-	-	34	side seam	34	seat	-	-	-	543	7	8
D4	3	seat	14	seat	-	-	11	side seam	29	seat	-	34	seam	650	16	35
E1	20	waist line	-	-	-	-	-	-	-	-	-	-	-	1000	6	9
E2	25	waist line	25	top	30	top	-	-	30	top	30	30	top	1000	31	13
E3	30	top	-	-	-	-	30	top	-	-	-	-	-	553	10	25
E4	52	top	-	-	-	-	-	-	-	-	-	-	-	525	17	11
F1	8	seat	16	seat	-	-	40	seat	-	-	23	-	-	525	13	16
F2	33	waist line	-	-	-	-	-	-	-	-	-	-	-	525	5	9
F3	12	under arm	34	seat	-	-	12	under arm	-	-	-	-	-	525	6	26
F4	5	seat	12	seat	16	top	16	top	16	top	-	16	top	500	5	9

Fabric Analysis

Results of fabric analysis of the 6 control slips appear in table 5. The number of threads per inch ranged from 189 to 150 for warp yarns, and 116 to 83 for filling yarns. Slip C, which gave the best service, had 38 more warp yarns and 33 more filling yarns per inch than the one giving the least amount of service, that is, slip F. "Best service" was determined by the condition of the slip at the end of the period of wear. In comparison to the slip giving the medium amount of service, slip C had 14 more warp and 29 more filling yarns per inch. The balance of threads in the best quality slip was 5:3, the others were about 2:1. A direct relationship seems to exist between service qualities of the fabric and the number of filling yarns per inch; likewise, between service qualities and balance of yarns.

The breaking strength ranged from 51.5 to 40.7 pounds warp wise and 39.3 to 15.1 pounds filling wise. Slip C, which was the best quality slip, tested 21 per cent higher in the warp and 44 per cent higher in the filling than slip F, the slip giving the least service. Slip C tested 16 per cent higher in the warp and 42 per cent higher in the filling than slip E, which gave a medium amount of service.

Elongation at the breaking point ranged from 0.79 to 0.50 inch for the warp, and 0.48 to 0.24 inch for the filling. The best quality slip, C, ranked 35 per cent higher in this quality in the warp and 5 per cent lower in the filling than slip F, the slip of poorest quality. In comparison to slip E, the medium quality slip, slip C ranked 35 per cent higher in the warp and 24 per cent higher in the filling.

The twist per inch in warp yarns ranged from 0 to 3. It may be assumed from this fact that the yarns were woven in the gum. The twist found in the filling yarns ranged from 26 to 46 per inch. No relation seemed to exist between the serviceability of the slip and the number of twists per inch in the filling yarns of the fabric.

The thickness of the fabric ranged from .005505 to .006560 inch. There seems to be no agreement between serviceability and thickness. The varying amounts of weighting found in the material probably influenced both serviceability and thickness.

The amount of weighting present ranged from 8 to 19 per cent of water soluble substances and from 0 to 45 per cent of insoluble material. All but one fabric contained from 29 to 45 per cent insoluble weighting. The best wearing slip had no perceptible insoluble weighting but contained 9 per cent of soluble substance. This is 10 per cent less water soluble weighting than the least serviceable slip. The fabric in the least serviceable slip was weighted with 29 per cent insoluble weighting in addition to 19 per cent soluble. Other than in the best wearing slip, there seems to be no agreement between the amount of weighting and the price.

Soluble weighting consisted of glucose, dextrin and cane sugar. The insoluble weighting was tin phosphate in each case.

The weight of fabric per square yard ranged from 50.81 to 67.52 grams. The fabric in the least serviceable slip weighed the least, that of the best wearing slip second. The fabric of the slip giving medium service weighed the heaviest, indicating the presence of a high percentage of weighting.

Shrinkage was determined by washing 3 pieces of fabric 6 inches square taken from each control slip. A 4 inch square was marked in each test piece with fine running stitches. The test samples were laundered in a reversing wash wheel machine of the cylindrical type. A 10 per cent solution of a mild soap was used. The samples were laundered for 60 minutes then dried on a perforated surface in a current of air. The dried samples were then dampened with water, allowed to stand for 5 minutes, then pressed. The shrinkage was the loss in each direction of the 4 inch square.

The 2 best wearing slips showed practically no yarn slippage either in the thumb test or after the period of service. The medium quality slips showed considerable amount of slippage both in the thumb test and after the period of service. The 2 least serviceable slips showed excessive amounts of slippage both in the thumb test and in the serviceability test.

The best wearing slip showed no shrinkage. Slips A, B, and E showed one-fourth to one-half inch shrinkage warp wise but none filling wise. Slips D and F gained one-half inch warp wise and slip E gained one-half inch filling wise.

Table 5. Fabric analysis of the 6 control slips.

A. Average thread count, tensile strength, elongation, yarn twist, weight per square yard, and thickness of the fabrics of the 6 control slips.

Slip no.	Thread count per inch: warp	Thread count per inch: filling	Tensile strength in pounds: warp new	warp aged	filling new	filling aged	Elongation in inches: warp new	warp aged	filling new	filling aged	Yarn twist per inch: warp	Yarn twist per inch: filling	Thickness in inches	Weight per sq. yard in grams
A	178.7	88.0	45.2	43.6	19.9	16.8	0.50	0.49	0.37	0.33	0	46	0.00654	61.77
B	175.8	87.7	44.2	40.6	18.7	16.5	0.52	0.52	0.40	0.38	2	26	0.00625	59.60
C	189.0	116.2	51.5	50.4	39.3	39.0	0.79	0.58	0.46	0.44	3	35	0.00636	53.79
D	170.0	83.3	42.0	42.0	15.1	15.0	0.55	0.54	0.24	0.20	0	40	0.00550	57.76
E	174.6	86.0	43.8	43.0	22.2	15.5	0.51	0.45	0.34	0.28	0	33	0.00656	67.52
F	150.4	83.3	40.7	39.8	21.7	19.2	0.51	0.47	0.48	0.29	0	40	0.00553	50.11

B. Average weighting, yarn and seam slippage of the fabrics, and shrinkage per yard of the 6 control slips.

Slip no.	Weighting: Per cent soluble	Per cent insoluble	Total per cent	Kind: soluble	Kind: insoluble	Slippage: Yarn	Slippage: Seam	Shrinkage per yard in inches: warp	Shrinkage per yard in inches: filling
A	8.5	33.5	42	glucose	tin phosphate	slight	slight	0.5	0.0
B	10.0	41.0	51	cane sugar glucose	tin phosphate	slight	considerable	0.5	0.0
C	9.0	00.0	9	glucose		none	none	0.0	0.0
D	13.0	39.0	52	cane sugar dextrin	tin phosphate	excessive	considerable	0.0	0.0
E	8.0	45.0	53	glucose	tin phosphate	slight	none	0.3	0.0
F	19.0	29.0	48	cane sugar glucose	tin phosphate	excessive	considerable	0.0	0.0

The best wearing slip, C, and slip E, the one giving medium service, showed no seam slippage in seams made along the bias. The grab method was used for this test. The material elsewhere gave way before the yarns or the stitches at the seams broke. Slip A, a medium quality slip, showed only a slight seam slippage while slips B, D, and F showed a considerable amount. Slippage, as determined by breaking strength, may be found in table 6.

Similar tests were made in a portion of the slip across which ran the seam joining the brassiere top and the skirt of the slip. Seams made parallel to warp yarns proved weakest. In the best wearing slip, yarns pulled out at 35 pounds. A similar construction was found in the poorest wearing slip which pulled out at 4 pounds. Seams running parallel to filling yarns pulled out at 35 and 45 pounds. Bias seams are decidedly stronger than those paralleling either the warp or filling yarns.

Table 6. Breaking strength of seams of bias silk slips.

Slip designation	Pull exerted in pounds	Where break appeared
A	45	seam
B	24	seam
C	54	fabric
D	26	seam
E	24	fabric
F	24	seam

The effect of synthetic perspiration on each control slip is shown in table 7. There seems to be a direct relationship between the amount of weighting and the percentage loss in tensile strength. The slip having the least amount of weighting materials, that is, slip C, lost the least strength due to treatments with synthetic perspiration; those slips having the highest percentage of weighting lost the most.

Table 7. Effect of synthetic perspiration on tensile strength.

Slip no.	Percentage loss			
	Warp		Filling	
	Acid	Alkaline	Acid	Alkaline
A	16.0	6.5	5.0	6.0
B	19.0	25.0	25.0	25.0
C	18.0	8.0	8.0	6.0
D	14.0	10.0	33.0	46.0
E	17.5	12.0	27.0	15.0
F	11.0	8.3	24.0	20.0

The tensile strength and elongation of new, aged, and worn slips is compared in table 8. In the most serviceable slip, the warp and filling yarns show about the same loss of tensile strength due to wear, while in all other slips there is much loss of strength in the warp yarns and almost none in the filling. This may be due to the large number of warp yarns which serve as a protection to the filling yarns, and also to the greater amount of twist in the filling.

The percentage loss in breaking strength due to aging was slight. In a majority of the fabrics it ranged from 1.8 per cent to 8.1 per cent. Slip B gave medium service and was the only one which lost as much as 19 per cent. This finding may mean that slip B was made of fabric that had been stored for some time. Slight loss was found filling wise.

Loss in elongation due to wear varied from 21 to 55 per cent in warp yarn and 13 to 39 per cent in the filling. The slip that gave best service lost most warp wise and the one giving poorest service lost the most filling wise.

Loss in elongation due to aging varied from 2 to 27 per cent in warp yarn and 2.5 to 39 per cent in filling.

Table 8. Tensile strength and elongation of new, aged, and worn slips.

A. Tensile strength of new, aged, and worn slips.

Slip no.	Tensile strength in pounds			Per cent loss tensile strength		Tensile strength in pounds			Per cent loss tensile strength	
	Warp			Warp		Filling			Filling	
	new	aged	worn	aged	worn	new	aged	worn	aged	worn
A	45.2	43.6	32.7	3.5	27.7	19.9	19.6	18.0	1.5	9.5
B	44.2	40.6	26.9	8.1	39.1	18.7	15.5	16.7	19.5	10.7
C	51.5	50.4	26.5	2.1	48.5	39.3	39.0	33.5	0.8	14.8
D	42.0	42.0	31.1	0.0	26.0	15.1	15.0	13.2	0.7	12.6
E	43.8	43.0	27.1	1.8	38.1	22.2	22.2	17.1	0.0	23.0
F	40.7	39.8	21.9	2.2	46.2	21.7	20.2	17.3	6.9	20.3

B. Elongation of new, aged, and worn slips.

Slip no.	Elongation in inches			Per cent loss in elongation		Elongation in inches			Per cent loss in elongation	
	Warp			Warp		Filling			Filling	
	new	aged	worn	aged	worn	new	aged	worn	aged	worn
A	0.50	0.49	0.36	2.0	28.0	0.37	0.33	0.32	10.8	13.5
B	0.57	0.52	0.45	8.8	21.0	0.40	0.39	0.32	2.5	20.0
C	0.80	0.58	0.36	27.5	55.0	0.46	0.44	0.38	4.3	17.4
D	0.55	0.55	0.35	5.5	36.4	0.24	0.20	0.19	16.7	20.8
E	0.51	0.45	0.32	11.8	37.3	0.35	0.28	0.24	20.0	31.4
F	0.52	0.47	0.36	9.6	30.8	0.48	0.29	0.29	39.6	39.6

The greatest service rendered by slip C may be accounted for in that the fabric was of better quality and the construction was superior to any of the other slips. The fabric showed a higher breaking strength, better balance of yarns, higher thread count, and no insoluble weighting. The lock stitch seam construction resulted in seams that would not pull out and were stronger than the fabric.

The poor service rendered by slip F was due to low thread count, high percentage of weighting, particularly the insoluble type, and poor balance of threads.

CONCLUSIONS

Based upon the limited findings of the present study, the following conclusions may be drawn:

Price seems to be an indication of quality in ready-made tailored slips.

Most fabrics used in silk slips were weighted to the extent that serviceability may be lessened.

The more nearly balanced the warp and filling yarns in silk fabrics the greater service that can be anticipated from slips made therefrom.

The wear given a slip seems to vary directly with the size and activity of the wearer.

Economy does not generally result from the purchase of low priced slips.

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LITERATURE CITED

Appel, W. G.
Silk weighting content. Textile World, 76: 46 p. Sept. 14, 1929.

Appel, W. G., and Jessup, D. A.
Accelerated aging test for weighted silk. National Bureau of Standards, 15: 601-608. Dec. 1935.

Bruner, Esther, and Goehring, Mina.
The deterioration of silks by light of different wave lengths. Textile Research, 5: 231-239. March, 1935.

Committee D-13 On Textile Materials.
American society for testing materials standards on textile materials. Philadelphia. American Society for Testing Materials, 295 p. Oct. 1936.

Cohen, Bertha, and Mack, Pauline Beery.
The effect of home laundry methods upon the breaking strength of unweighted and weighted silks. Jour. Home Econ. 21: 854-855. Nov. 1929.

Cormany, Esther M.
The effect of ultra-violet radiation and perspiration on the breaking strength of certain silk fabrics. Unpublished thesis, Kansas State College of Agriculture and Applied Science, 27 p. 1932.

Hillebrand, W. F., and Lundell, G. E. F.
Applied inorganic analysis. New York. John Wiley and Sons, 929 p. 1926.

Jackman, Agnes, and Rogers, B.
The principles of domestic and institutional laundrywork. London. Edward Arnold and Co. 216 p. 1934.

Keeney, Pauline, and Fulton, George Power.
Analysis of silk dress fabric for college girls' uniforms. Unpublished study. Pennsylvania State College, 1932.

Laramy, Mary.
Study of silk underslips. Unpublished study. Pennsylvania State College, 1933.

Mack, Pauline Beery, and Cooke, Geraldine.
How silk dresses wear. Jour. Home Econ. 23: 938-939. Oct. 1931.

Preston, Albert B., and Johnson, Otis, C.
Qualitative chemical analysis. New York. D. Van Nostrand Co. 745 p. 1925.

Roberts, Nellie Myres, and Mack, Pauline Beery.
The effect of artificialperspiration on the breaking strength of weighted and unweighted silk. Jour. Home Econ. 24: 450-456. May, 1932.

Ross, Jeanette E., and Edgar, Rachel.
Cleaning of weighted silk fabrics. Jour. Home Econ. 27: 106-110. Feb. 1935.

Southard, Julia Lurena.
The effect of perspiration on the breaking strength of selected silk fabrics. Unpublished thesis, Kansas State College of Agriculture and Applied Science, 28 p. 1930.

Whitlock, Mary C.
Wearability of silk dresses. New York. National Federation of Textiles, Inc. 54 p. 1936.

APPENDIX

Directions for Wearing and Laundering Slips

Wear the slips for 500 hours then report the condition of the slip to me. It is possible that the slip may be worn 1500 hours or more. Since all the slips are to be worn the same length of time and the slips vary in quality, I will need reports at stated times. Keep the slip in as constant wear as possible, leaving only a minimum length of time for laundering.

Laundry method. Use a suds of "Lux" and luke-warm water. Squeeze instead of rub the slip when washing. Rinse in luke-warm water until no trace of soap appears. Roll in a towel to absorb the moisture for not more than 10 minutes, then iron. If it is not convenient to carry out this method, dry the garment, then dip in water, roll in a towel for 10 minutes and iron.

Iron in the direction of the thread of the material with a moderately hot iron.

If a hole appears in the garment, return with the record at once.

Concerning the Wearer of the Slip and the Service Record of the Garment

Name of wearer ________________________

Address of wearer _____________________

Main occupation of wearer _____________

Height of wearer __ ft. __ in.   Weight _____

Age: Under 25 ___   Over 25 ___

Do you move quickly _____ or deliberately? ______

Do you consider that you are hard ___ or easy ____ on your clothing?

Do you drive a car a great deal? Yes ____   No ___

Do you have any other activity which will affect the durability of a slip? Yes ____ What _______   No _____

Where do your slips wear out first? __________________

Do you perspire freely? Yes _____   No _____

Do you use an astringent? Yes _____ What _____   No ____

Do you use a deodorant? Yes ____   What _______   No ____

Has the slip been scorched? Yes ______   Where? _____ No __

Pulled areas noticed after ___ wearings and ___ launderings. Where? ________

Hole noticed after ____ and _____ launderings. Where? ___

Straps needed fastening after ___ wearings and ___ launderings.

Repair needed after ____ wearings and ____ launderings.
How? _____

Thin spot noticed after ____ wearings and ____ launderings.
Where? ________________