A COMPARISON OF TWO LAUNDERING PROCEDURES FOR WHITE NYLON SLIPS

Thesis for the Degree of M. A.

MICHIGAN STATE COLLEGE

Beulah Loraine Davidson

1953

This is to certify that the

thesis entitled

A Comparison of Two Laundering Procedures
of White Nylon Slips

presented by

Beulah Loraine Davidson

has been accepted towards fulfillment
of the requirements for

M. A. degree in Textiles & Clothing

Hazel B. Strahan
Major professor

Date May 26, 1953

A COMPARISON OF TWO LAUNDERING PROCEDURES FOR WHITE NYLON SLIPS

By

Beulah Loraine Davidson

A THESIS

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Textiles, Clothing, and Related Arts

1953

THESIS

ACKNOWLEDGEMENTS

The writer wishes to express her sincere appreciation to Miss Hazel B. Strahan, Head, Department of Textiles, Clothing and Related Arts, Michigan State College, for her guidance and supervision of this thesis; and to Miss Sarah Brier, instructor in research, for her willing assistance in the testing laboratory.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES AND CHARTS

INTRODUCTION

I. INTRODUCTION

The many new true synthetic fibers such as orlon, acrilan, dynel, or nylon which we consumers enjoy today may be considered dividends from the previous years devoted to basic research. The technological developments in the earlier semi-synthetics, rayon and acetate; and much of the fundamental fiber research has been done since the close of World War I. Since 1918 rayon and acetate have undergone many improvements and have largely replaced silk in many products. Nylon became available, less than fifteen years ago and has, perhaps, had greater growth in total production and acceptance by the trade and consumer than any of the other fibers. The acceptance of nylon for its many diversified uses is unquestionably due to its inherent characteristics and performance in use. Nylon's superior strength, abrasion resistance, ease in care, retention of shape, draping qualities, and chemical resistance are significant reasons for its sensational rate of increase within a decade. Knit construction has been particularly well accepted because it permits evaporation of perspiration better than the woven lingerie fabrics.

Discoloration of white nylon lingerie washed with synthetic detergents has, however, been a common complaint among consumers. Repeated launderings seemed to result in progressive grey or yellowish discoloration.

The purpose of this study was to investigate the effect of two laundering procedures on the extent of discoloration in white nylon tricot and white satin slips. Comparison of dimensional change in the slips by two methods of laundry; analysis and comparison of physical properties and performance characteristics of the new fabric with those same properties and characteristics after laundering, constituted the other objectives for this study.

For a more valid determination of total serviceability expected from a garment, it would be desirable, in conjunction with laboratory analysis to carry out a wear study in which the garments would be subjected to normal use and care. Since perspiration, body strain and other factors affect serviceability and satisfaction in use, wear studies are more inclusive of the variables involved in a garment's performance and total serviceability. Because wear studies involve a much longer period of time for investigation, this study was limited to laboratory analysis for determination of the effect of two different

methods of laundering on service qualities and color change in white nylon tricot knit and white nylon satin.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The development of nylon evolved when Du Pont chemists began a new program of fundamental research in 1928. It is a classic case of a new material developed in little more than one decade. The new fabric did not receive the name "nylon" until 1938. It has won great favor because of its strength and lightness; its washability and quick drying qualities; its resistance to wear; resilience and ability to hold its shape in use. (12)

Du Pont, the sole producers of nylon yarn in the United States at the present time is manufacturing staple fiber and filament yarn at the combined rate of 145,000,000 pounds per year, thirty three per cent of which is going into military uses. Greater production is expected in the future since the demand for it has been greater than the available supply. (5)

Not only has nylon been used extensively for woven lingerie but its use in tricot knit goods has increased tremenduously in popularity since the close of World War II. (34) By 1952 nylon has become the key word in the tricot field because finished nylon tricot fabrics have excellent stretch and recovery properties, softness, drapability and porosity. (4) Tricot fabrics, prior to the close of World War II were manufactured on a limited scale. Celanese is generally credited with being the pioneer in the manufacture of tricot goods for the underwear trade and mass market. The popularity of tricot knit is shown by the operation of more than 2400 tricot machines in 1951, compared with 1100 in 1941. Nylon fibers are, in general, stronger and smoother running on the tricot machine than cotton or rayon. Nylon tricot cloth can now be made satisfactorily on the new high speed machinery without the manufacturing defects which plagued the knit wear industry when they tried to use silk, cotton, rayon and acetate.

Factors such as dimensional stability or resistance to distortion and creasing are the two most important properties associated with high quality performance in a textile material. In cotton goods, dimensional stability is accomplished by methods based upon compressive mechanical shrinkage. Regenerated cellulose rayons, on the other hand, do not respond well to this type of treatment so some form of resin or chemical stabilization is generally adopted. Loom-state nylon fabrics, like those made from other textile fibers; have a tendency to shrink. This shrinkage may be eliminated by treatment with boiling aqueous liquors during processing or in the process of setting. This process of setting, besides imparting the required degree of dimensional stability, is also capable of imparting a permanent shape to nylon fabrics. This precludes the formation of permanent creases during processing and the finished fabric has resistance to distortion and quick recovery from creasing. The setting of nylon may be defined as the reduction or elimination of subsequent yarn shrinkage. It enables the yarn to assume the configuration in which it has been held during the setting treatment. The degree of set or stability which is achieved depends, to some extent, upon the degree of shrinkage allowed during the setting procedure. Conversely, subsequent yarn shrinkage after setting depends on the severity of the processing procedures in setting as well as the method of test for any subsequent shrinkage. (16)

Studies relating to the service qualities of nylon fabrics of significance to this investigation are relatively few. Fletcher, Duensing, and Gilliam (8) of the Bureau of Human Nutrition and Home Economics studied sixteen fabrics, knitted to specification in the Bureau's laboratory. Medium staple cotton, wool, filament rayon and filament nylon constituted the four groups studied. They found greatest dimensional change usually occurred in the first laundering. All fabrics except the plated nylon of forty courses per inch, exhibited considerable lengthwise shrinkage. The nylon fabrics changed the least in width of any of the four groups. Less lengthwise shrinkage occurred in the knit fabrics of forty courses than those of thirty two courses per inch. (8) Also it was found that knitted fabrics usually shrank more in length than woven fabrics of similar fiber content.

In another study, Fletcher and Roberts (9) observed the geometry of knit fabrics made of staple rayon and nylon and determined their relationships to shrinkage in laundering. These fabrics were knit of the different yarns under controlled conditions in the Textile Research Department of the American Viscose Corporation. They found nylon fabrics changed the least in both length and width. All "grey" fabrics shrank more than ten per cent in length in five launderings. All of the loosely knit "grey" materials, except the plain knit nylon, stretched excessively in width. Area shrinkage in all of the "grey" fabrics and the finished viscose fabrics increased with knitting stiffness. Area shrinkage in the finished acetate-viscose, and nylon materials usually decreased as the knitting stiffness increased.

Weiner (30) reported studies made on the effect of knitting and finishing variables on the shrinkage of typical Quartermaster Corps cotton underwear construction. Factors analyzed were yarn count, knitting stiffness, and stitch type in relation to reducing potential laundering shrinkage. Since the dimensional stability of woven fabrics is related to tightness of weave; fabrics with well packed warp and filling yarns are subject to less laundering shrinkage than the more open weave structures. Similarly it was found the lengthwise shrinkage of knit fabrics was less severe when coarser yarns were used. However, the use of heavier yarns resulted in greater widthwise shrinkage. The improved control of lengthwise shrinkage that occurred when heavier yarns were used may be explained by the closer packing of the fibers and yarns which takes place; resulting in increased fabric density. Fabric weight was also increased by the use of the heavier yarns. Tests made with different knitting stiffness showed that those with the greater number of courses per inch were subject to less lengthwise shrinkage but to more shrinkage in width. For a given degree of improvement in laundering stability, increasing the number of courses per inch resulted in much less change in width and weight of the fabric than increasing the size of the yarn.

Alexandra and Sturley (1) investigated the influence of twist on breaking load and breaking extension of continuous multifilament nylon yarns and monofil. Commencing with three-four S twists per inch, curves showing twist against average breaking load for regular 30, 45, and 60 denier multifilament yarns exhibited an increase in breaking load to a maximum as additional twist was inserted. Further insertion of twist showed the breaking load decreased continuously to the limit of seventy twists per inch. Twist setting the three-four S twists per inch yarns, produced an increase in breaking load of approximately five per cent.

The public relations department of E. I. Du Pont De Nemours and Company suggests that fabrics made entirely of nylon may be washed with the same soaps and synthetic detergents used for general laundering, provided the dyes and finishes are truly washable. Garments can either be washed in warm sudsy water by hand or in the washing machine. The latter method can be used satisfactorily where there is no hazard of fraying. They stress the fact that to keep white nylon white, it must be washed separately. Although colors in other garments may appear to be fast, they often leave enough discoloration to bring about an objectionable "off white" tinge to white nylon. When washing white nylon in hard water a soap which softens the water should be used to prevent the deposit of curds of insoluble soap on the fabric which give white garments a grey cast. (20) This grey cast particularly in cotton, has been found to result from soil redeposition. Tests have shown that many detergents have poor soil suspending characteristics and permit the retention of soil over a period of washings.

In a study conducted by Roseberry and McKee (17), soil removal from nylon was observed in various procedures. The study proposed to determine the best conditions for washing nylon for maximum soil removal. Various detergents, concentration of detergents and temperature of water were used. They found that at a concentration of .075%, the detergents could be ranked from best to poorest in the following order: non-ionics, sulfonated amides, alcohol sulfates, soaps and alkyl aryl sulfonates. At a .15% concentration the order changed with soaps leading in soil removal followed by the alcohol sulfates and alkyl aryl sulfonates. At a .3% concentration the order is the same as that at .15%. At .075% concentration the soil removal power of a built soap and non-ionic detergent increases. Raising the temperature of the water from 120° to 130° F. resulted in significantly more soil removal in the built soap but no increase resulted from further temperature increases. The effectiveness of the non-ionic detergent continued to increase as the temperature increased.

Leonard and Schwartz (14) report that in 1936 Krueger made a microscopic study on the soiling of garments which had been worn and showed the contamination of cotton fibers in those garments by secretion from sweat glands and hair. It was concluded from these experiments with cotton fabrics of various constructions, that the degree of soilage and resistance to its removal depends on the solubility of the skin excretions and the nature of the fabric construction. Open weaves permit dirt to penetrate while surfaces that are close and even, and starched are resistant to contamination. They also found that fine fibers retain soil more readily than coarse fibers, and that fibers with uneven cross-sectional contours retain soil more readily than those with smooth circular contours. Nylon belongs to the latter group.

Snell (22) reports the alky sulfates, sometimes termed fatty alcohol sulfates, paved the way for broadening the field of detergents. By 1930 they were commercially successful. Coconut oil is the fat source commonly used since it has the desired average chain length of carbons. As with the alkyl aryl sulfonate, some sodium sulfate is produced as a natural step in manufacture. The cost of the active detergent is off-set by building with about seventy five per cent of other ingredients. This type also requires correction in building to give good detergency on cottons. The detergent used for this investigation contained about twenty five per cent of the alkyl sulfate built with sodium sulfate, a polyphosphate and a few per cent of carboxymethyl cellulose. This compound commercially known as Tide is said to be a better detergent than soap for washing cottons. Alkyl sulfates are more resistant to hard water than alkyl aryl sulfonates. Snell further states that synthetic detergents must be used under optimum conditions for the particular job to be done. For example, strong agitation promotes any detergent process. Experimental work applying standard washing procedures has shown that mechanical action alone frequently does one-third to one half of the total scouring.

In another study Snell (25) reported that soap would always be used under the proper conditions of water softness and alkalinity for washing cotton. However, in studies comparing soap with an alkyl aryl sulfonate, the latter proved to be somewhat less effective than soap in washing light weight silk dress fabrics, fiber glass textiles, nylon knit goods, cotton, rayon, and rayon given crease resistant finish. In some cases, differences were not great between the soap and the detergent. Nylon was washed easily by both.

Furry, McLendon, and Aler (11) conducted a study to determine the efficiency of soaps and synthetic detergents for use in home laundering. Fifteen soaps, one soap powder, and thirty five synthetics detergents were evaluated for their effectiveness for removing soil under standardized conditions. The change in light reflectance produced in the laundering of artificially soiled cotton fabric was used as a measure of the soil removing efficiency of the different detergents. Samples of the test fabric were laundered in the Launderometer at 127° F and 84° F for fifteen minutes in distilled water and in water of 150 and 300 parts per million hardness at five different concentrations of the detergent. It was found that the soaps removed considerably more soil at 127° F in both distilled and hard water than at 84° F. In hard water the synthetic detergents, in a majority of cases, were more effective than the soaps, especially at concentrations lower than .35 per cent.

Snell (24) states that most of the research on laundering textiles with synthetics detergents has been carried out on either cottons or wool. The fiber's physical nature enters into washing conditions in the selection of optimum temperature and pH of the wash solution, but the fiber's chemical nature is more directly related to the action of a particular detergent. "When synthetic textiles resemble neither the cellulose of cotton nor the protein of wool; research investigations, methods and conditions of scouring would be of great value."

Relatively few serviceability studies on nylon slips have been conducted to the present time. However, in 1949 Kroll and Williams made a study of snagging in nylon tricot slips. They found that snagging in the slips studied resulted from the wearer shaving her legs. The stiff hairs pricked the nylon fibers. Why did the nylon tricot slip show this snagging condition when it did not appear in tricot slips made of other fibers? A comparison of nylon with other fibers in knit tricot indicated that the looped effect caused by snagging in the nylon was a result of the strength and smoothness of the individual nylon which permitted a pulling action. With other fibers no looped conditions resulted because the obstructions causing the snag easily broke the individual filament. It was found, however, that snagging could be decreased by increasing the denier of the individual nylon filament to a point where the stiff hair bent rather than pulled the filament. With this thought in mind, slips were thereafter made of forty denier - thirteen filament yarns where previously they had been made of forty denier- thirty four filament yarn. In other words the yarn size was increased to overcome snagging.

Several studies of rayon slips have been made. In 1946 Rann (22) made a laboratory study of four different brands of rayon crepe and rayon satin. The slips were laundered thirty times. She found maximum shrinkage occurred in the first laundering. Shrinkage was somewhat more progressive than the crepe as laundering was continued. However, wider variation was found in the measurements after launderings, due to the bias cut of the garments. The results of her study indicated that the measurements of a bias cut slip after laundering, are highly dependent upon both laundering and the ironing procedure. The average percent shrinkage which occurred was sufficiently high to materially affect the fit of the slip. Improved methods of shrinkage control were badly needed for woven rayon slips. Tensile strength consistently increased through the twentieth laundering. Thereafter slight decreases in strength were noted.

Thompson (32) carried out a "wear" study on eighteen rayon slips. Thirty three rayon slips of one style and brand were purchased. Eighteen were worn by cooperators engaged in similar occupations for 750 hours. Twelve of them were laundered in the home and the other six laundered in the laboratory under controlled procedures. Six unworn slips were laundered in the laboratory and served as laundered controls. Thompson found that yarn count increased progressively through ten launderings and, in some cases through twenty, tending thereafter to stabilize or decrease. There was corresponding increase in weight per square yard. Warp breaking strength loss was greater in the worn slips which were laundered by the cooperators. The worn slips showed significant evidence of deterioration; in fact a few of the slips were ready to be discarded after thirty launderings. The greatest deterioration was observed on the inside of the double edge stitched bodice top, particularly across the back and underarm sections.

Bayor's (3) study compared the service qualities of thirteen slips each in three different brands of rayon warp knit. Two brands were two-bar tricot construction, the other a single atlas. The study was carried out to compare by laboratory tests, the physical properties affecting dimensional change and serviceability in repeated launderings. Inasmuch as shrinkage is a characteristic problem in knit fabrics, a comparison of fabric shrinkage and dimensional restorability by the use of three different drying procedures was the second aspect of the study. There were obvious changes in the slips as the number of launderings increased. In each brand there was increase in wale and course count. Weight and thickness of the fabric increased through the fifteenth laundering and decreased thereafter. The same pattern of increase and decrease occurred in bursting strength. Two brands had a significant correlation with the number of launderings.

MATERIALS AND METHODS

III. MATERIALS AND METHODS

A. ORGANIZATION OF THE STUDY

Selection of Slips

Six white nylon satin slips and six nylon tricot slips were purchased in a local store in May, 1952, for this laboratory study. The tricot slips were all of the same design and ranged in sizes from 34 to 38. The satin slips were also alike in design of sizes ranging from 12 to 16. The Barbizon satin slips cost $5.95 each and the Vanity Fair tricot cost $4.95 each.

The satin slips were cut on the bias with a four gore skirt construction. The side front and back were cut in one piece to eliminate the side seam. (See plate in appendix). The satin slips were lace trimmed and had lapped zig zag stitched seams with pinked edges. The tricot slips had a three gore skirt construction with one gore across the front and two for the sides and back. The seams used in the construction of the slips is referred to in the knitting trade as a serged seam. This over-edged seam is desirable for knitted garments because this stitch permits more stretch without breaking. The hems and top of the front and back bodice yoke were double stitched. One slip of each type was kept as a control. One each of the satin and tricot were divided in half so that test samples for weight and color change could be withdrawn at specified intervals for each method of laundering. The remaining eight slips were used for physical testing after laundering. (See plates I and II in appendix for samples of the original and laundered fabrics.) Four slips were withdrawn after ten launderings for physical testing. The four remaining slips were carried through thirty five launderings. The slips were soiled with a modified standard dry-soil mixture before laundering and after each five subsequent launderings. In order to make shrinkage determinations, each slip was marked at specified points. At specified laundering intervals, measurements were taken at these points and recorded to the nearest one sixteenth of an inch.

The tricot slips were laundered according to a modified procedure used by Bayor (3) in her study, "Comparison of Some Physical Properties Affecting Service Qualities of Three Brands of Rayon Warp Knit Slips". The hand laundering procedure for the satin consisted of wetting out the slip for three minutes and then gently squeezing the suds through the fabric for three minutes. The soap solution was made of one half cup of detergent to eight gallons of water of $110^{\circ} \pm 5^{\circ}$ F. The water was gently squeezed from the slip, then rinsed for two minutes in clear water at 100° F followed by a second and third two minute rinse. After the third rinse the slip was rolled in a towel to remove excess moisture and allowed to remain for thirty minutes. The slips were then ironed with the heat control set on rayon (225° to 275° F). The iron was raised and lowered, or rather, no pushing motion was used so as to minimize stretch. The slips were then placed on a flat surface and allowed to dry six hours before being measured. The tricot slips were similarly laundered but dried differently; that is, pulled to shape and freed of wrinkles then hung by the straps until dry.

The machine laundering procedure was as follows: The slips were run for fifteen minutes in an agitator type washing machine. The same soap solution and amount of water were used in the machine as used in hand laundering. The temperature of the water, however, was $120^{\circ} \pm 5^{\circ}$ F. After gently squeezing the sudsy water from the slips, they were rinsed for two minutes in clear water at 110° F. After the second rinse they were agitated for five minutes in clear water of the same temperature. They were dried in the same manner as the hand laundered tricot slips.

Measurement of the Garments

In order that shrinkage measurements be taken on the slips at the same location at each interval, thread markings were made at designated locations on each slip. Three horizontal measurements were taken in both the satin and tricot slips; namely, at the bust, waist and hip. Six vertical measurements were taken in the tricot center front, center back, side seams, and side front. The seven vertical measurements in the satin were taken at center front, side fronts, side seams, and side back. Measurements at these points were taken following each laundering through the fifth and again after the tenth, twentieth, and thirty fifth. To take the linear measurements the garment was placed over an ironing board. A firm measuring tape was then placed on the slip closely following the thread marked line. Care was taken not to move the slip during the measuring procedure. Measurement for that line was recorded and the slip shifted to the next line for measurement. The same procedure was followed for all linear measurements. Due to the fact that knit goods and garments cut on the bias stretch in handling; the width measurements were taken across one half of the slip while it was lying flat on the ironing board. This measurement was doubled and recorded as the measurement for that horizontal line.

B. LABORATORY TESTS

The following tests were done under standard conditions of 65% $\pm$ 2 relative humidity and temperature of 72° $\pm$ 2° F.

Twist. The Suter Twist Tester was used to determine the number and direction of twist in warp and filling yarns according to the Platt method. A five inch yarn ravelled from the fabric was fastened into the tester so that a three gram deflection load depressed it one eighth inch. One yarn was twisted until broken, a second yarn untwisted and then retwisted until broken. The following formula was used in determining the twist per inch.

$$t = \frac{N_1 - N_2}{2} = \frac{T}{L}$$

N_2 = number of turns to twist to rupture
N_1 = number of turns to untwist and retwist to rupture
T = total of number of turns in yarns
t = turns per inch
L = length of yarn used

An average of ten determinations each was computed as turns per inch for warp and filling yarns respectively.

Denier. The Universal Yarn Numbering Balance was used to determine the denier according to the method and procedure outlined in A. S. T. M. (2). Yarns ninety centimeters in length from warp and filling, were measured with a steel rule accompanying the instrument. Each yarn was then looped and hung on the balance by a single yarn in such a manner that it was not touching any other part of the instrument. The beam clamp was released and the index pointer rotated until the beam was in balance. The index pointer indicated denier. Ten determinations each for warp and filling were recorded and the averages computed.

Filament Count. Filament count was made by placing a yarn on a piece of black velvet. Five filaments were counted and pinned to the velvet until the counting was completed. The number of pins multiplied by five plus any remaining filaments constituted the filament count for that yarn. The average of the count of five yarns from both warp and filling were recorded as filament count for warp and filling respectively.

Course Count. The number of wales and courses per inch were determined by counting a space of two inches from at least five different places on the fabric with a Lowinson micrometer. The material was laid on a table without tension while the wales and courses were counted. The arithmetical average of five determinations, with no two areas including the same set of courses or wales was recorded as wale and course count.

Yarn Count. A Lowinson micrometer was used for counting the number of yarns in an inch for both warp and filling. Yarn count was recorded as the arithmetical average of

five determinations for each with the count taken from no two areas including the same set of yarns.

Thickness. The thickness of each fabric was determined by the use of the Scheifer Compressometer. A foot, one inch in diameter, was lowered on the specimen until one pound of pressure was exerted. The thickness of the fabric was recorded in inches. Three readings were taken on each specimen and the average computed. The thickness was determined on the original, and again after the tenth and twentieth launderings.

Weight in Ounces per Square Yard. Weight per square yard was determined in accordance with the method outlined in A.S.T.M. (2). Five specimens two inches square, were taken at random from the fabric and weighed on a chainomatic balance. The weight per square yard was computed by the following formula:

$$\frac{45.71 \text{ grams}}{\text{Area in inches (20)}} = \text{ounces per square yard}$$

Bursting Strength. Bursting strength was determined in accordance with the A.S.T.M. standard procedure. A Scott Tensile Testing machine equipped with the ball bursting attachment was the instrument of test. Five samples, four and one fourth inches square were cut for determination of the dry bursting strength. The specimens were inserted and held securely in a clamp mechanism under a tension which was uniform in all directions. The clamp mechanism is 1.7500 inches in internal diameter. The center of the specimen was pressed against a polished steel ball 1.0000 inches in diameter until the specimen burst. The direction of the bursting motion of the ring clamp was at right angles to the specimen being burst. Five wet specimens after being immersed in water for two hours were burst in the same manner as the dry. The average bursting strength recorded for both wet and dry was the arithmetical mean of the results of five tests for each.

Breaking Strength. Breaking strength was determined on the Scott Tester by the ravel strip method outlined in A.S.T.M. (2). Ten specimens each one and one fourth inches by twelve inches were cut for both warp and filling with the longer direction parallel to the yarns being tested. Each strip was ravelled to one inch in width with approximately the same number of yarns taken from each side. Test specimens were then cut into two six inch strips; one set for dry and the other for wet breaking strength determinations. No two specimens for warp or filling contained the same set of yarns. The samples for wet breaking strength were broken after immersion in distilled water for a period of two hours. Specimens were broken within two minutes after their removal from the water. Recordings were made to the nearest one half pound. The average of the ten readings each was recorded as the dry and wet breaking strength in pounds for warp and filling.

Elongation. Elongation of the fabric was taken simultaneously with tensile strength by the autographic recording device on the Scott Tester. Elongation was calculated from the start of the line on the tensile gram and an average of ten determinations each for wet and try tests was recorded as the average percentage increase in length for warp and filling.

Abrasion. Resistance to abrasion was determined on the Taber Abraser. Three specimens five by five inches were abraded with CS 10 Calibrase wheels under 500 grams pressure. Specimens were abraded for determining first sign of wear, arbitrarily defined as the first yarn broken, and then to a hole; defined as the rupture of two yarns at right angles to each other. The remaining two specimens were abraded to a constant number of cycles. The constant number was arbitrarily determined; falling within the maximum and minimum range of cycles for first sign of wear and a hole.

Drapability. The drapability of the fabrics was determined on an improvised drapemeter patterned after the one developed by John H. Skinkle and Arthur J. Moreau (21). The drapemeter consisted of two ring stands supporting a horizontal rod on which three, two and one half inch paper clips hung. A second ringstand with a clamp held a millimeter rule exactly 100 millimeters below the jaws of the paper clamps. Three specimens 100 by 250 millimeters each for warp and filling with the short dimensions parallel to the set of yarns being tested were folded lengthwise with the face of the fabric on the convex side, and placed in the clamp one fourth inch below the end of the fabric. The fabric was allowed to hang undisturbed for two minutes. The millimeter scale was then moved to the two edges of the fabric on the concave side and the chord length read in millimeters. Since the specimen was 100 millimeters in width, the reading would also be the percentage of the width. The arithmetical averages for each set of warp and filling yarns were determined and the geometric mean of each was computed and recorded.

Friction. The instrument of test for determining the kinetic friction of the slip fabrics against another fabric, was the Dreby Friction Meter. Test method and procedure of the A.S.T.M. (2) was used. A sample of the fabric, four by twelve inches, was laid face down on the polished horizontal surface under a polished one pound weight, three by three and one half inches. A sample of the same size as the other fabric was attached to the drum and withdrawn at a speed of about thirty inches per minute. On turning the drum, the lower sample was withdrawn imparting a frictional drag to the upper sample which was recorded on the dial. Readings from the dial were recorded as the unit coefficient of kinetic friction.

Color. A disk colorimeter was used in color tests. The disks were made of two neutral colors and two other colors. For this problem, complimentary colors of the Munsell Color System were used. The disks were cut from Standard Munsell papers. These disks had a radial slit extending from a center perforation to the circumference, so that two or more discs might be interwoven, with a portion of each remaining visible. The disks were placed on a motor and spun rapidly enough to eliminate flicker. The color resulting from this mixture depended upon the relative amounts of the exposed areas of the several disks used. All colors which lie within the region bounded by the colors of the disks could be matched by the mixture. The measurement was recorded in terms of the exposed proportions of the disks in the matching mixture. Five readings for each sample were taken and the average calculated. Tests were made on the original fabric and after each five subsequent launderings.

DISCUSSION OF RESULTS

IV. DISCUSSION OF RESULTS

A. ANALYSIS OF ORIGINAL FABRICS

An analysis of the results of physical testing of the new fabrics and those laundered both by hand and by machine was made to determine significant differences or similarities in the two methods of laundry. The physical tests carried out on the new fabrics were yarn analysis consisting of denier, filament count, and twist; and fabric analysis for weight per square yard, yarn and course count, bursting strength, breaking strength and elongation, abrasion, friction, drapability and color change.

Fiber Content

Miscroscopic and chemical analysis were made to verify the fiber content of the slips. The fibers were immersed in a ninety per cent phenol solution in which nylon is soluble. From the reaction obtained it was concluded both the slip fabrics were 100 per cent nylon.

Yarn Analysis

Analysis of the yarn of the satin slips included denier, filament count and number of twists per inch. Due to the construction of the fabric, it was not possible to analyze the yarns of the tricot. However, the tricot was sold as having been made of thirty denier yarns. The warp and filling yarns in the satin were almost identical in denier and filament count; denier of forty four and forty six respectively in the warp and filling. Filament count was thirty four for the warp and thirty three in the filling yarns.

In determination for twists per inch, it was found that the filling yarns had about five times as many twists as the warp with eighteen turns per inch. Both warp and filling were given a Z twist. Alexandra and Sturley (1) found that with an addition of twist the breaking strength increased to a maximum but further insertion of twist resulted in breaking load decreases continuously to the limit of twist or seventy turns per inch.

Yarn Count

The satin fabric was not a balanced construction; the ratio of warp to filling being one to two and one half; characteristic in satin constructions. The warp yarn count was 293; the filling 129 yarns per inch.

Course Count

In the tricot fabrics, there were almost twice as many wales as courses per inch. The original wale count was fifty five and the course count thirty per inch.

Weight in Ounces per Square Yard

The weight per square yard was calculated from samples which had been conditioned for at least four hours under standard conditions for testing textiles. Original weights of both the satin and tricot were similar, varying only one tenth of an ounce. The satin and tricot weighed two and one half ounces and two and four tenth ounces per square yard. Although the satin was slightly heavier in the original; that was due, in part, to soluble sizing. This assumption is later substantiated as the satin became progressively lighter after laundering while the tricot increased progressively in weight.

Thickness

Original thickness measurements showed the tricot approximately forty per cent thicker than the satin. Original values were .0103 inches for the tricot and .0061 inches for the satin. This does not parallel weight differences since both the tricot and satin were of approximately the same weight. The satin was compact in structure with a high yarn count. The looped construction of tricot was responsible for its greater thickness.

TABLE I

Original Specifications

Fabric	Filament Count[1] W	Filament Count[1] F	Denier or Number[2] W	Denier or Number[2] F	Twist Per Inch[3] W	Twist Per Inch[3] F	Yarn Count[4] W	Yarn Count[4] F	Course Count[5] Wales	Course Count[5] Courses	Weight Per Sq. Yd. in Ounces[6]	Thickness in Inches[7]
Tricot			30	30					54.6	30.5	2.3520	.0103
Satin	33.6	32.8	44.2	45.7	18.34	76.04	293.0	129.4			2.4999	.0061

[1]Ave. of 5 determinations

[2]Ave. of 10 determinations

[3]Ave. of 10 determinations

[4]Ave. of 5 determinations

[5]Ave. of 5 determinations

[6]Ave. of 5 determinations

[7]Ave. of 5 determinations

B. PERFORMANCE TESTS ON ORIGINAL FABRICS

Color

In the original fabrics the satin had a ninety five per cent whiteness and the tricot had eighty six per cent.

Breaking Strength

The dry warp breaking strength of the new satin fabric was more than twice that of the filling; dry strength of seventy two pounds in the warp and thirty one in the filling. While the wet breaking strength was lower than dry, its ratio of warp to filling strength was the same as the dry. One of the significant features of nylon is its high wet-dry strength relationship -- wet strength being eighty to ninety per cent of dry. The nylon satin in this study was approximately eighty per cent of dry which falls within the expected range. The fifty six pounds wet strength of the warp was likewise approximately eighty per cent of its dry strength.

Elongation

The per cent elongation of the new satin fabric was approximately the same for both warp and filling. Dry elongation was twenty three per cent and twenty two per cent for warp and filling respectively.

TABLE II

Original Performance

	Percent Whiteness on Color Wheel[1]	Breaking Strength[2]				Elongation[3]				Bursting Strength[4]	
		Dry		Wet		Dry		Wet		Dry	Wet
		W	F	W	F	W	F	W	F		
Tricot	86									103.4	88.4
Satin	95	71.8	30.9	55.6	23.8	23.48	21.8	20.73	18.59		

[1]Ave. of 5 determinations
[2]Ave. of 10 determinations
[3]Ave. of 10 determinations
[4]Ave. of 5 determinations

Abrasion

There is, as yet, no standard method in performing and evaluating abrasion tests as test results obtained from different instruments show considerable variation. Skinkle (21) states that in many cases, the order of resistance of fabrics to abrasion is also the same as the order of wear; but in many cases, the order is different. Fletcher and Gilliam (10) tested four rayon fabrics used in women's slips to determine whether the laboratory abrasion test could be used as predictive of wear. They found that the relative performance of garments made from rayon crepe similar in construction, can be predicted from laboratory tests of the abrasion resistance of the fabric from which they are made.

In the tricot fabrics, the first sign of wear occurred at 150 cycles. Before an actual hole appeared in the satin, 610 wear cycles were run, which is approximately three times the number for the tricot. However, apparent abrasion of the long floats before the first hole appeared rendered the fabric objectionable in appearance to the extent that the wearer would consider it worn out. In fact, it was worn out in the direction of the warp.

Drapability

The drapability of the tricot could not be computed since the reading in the filling direction was zero, which indicated excellent draping qualities. The drapability value for the satin fabric was twenty one which indicated that the satin also had good draping qualities.

TABLE III

Original Performance

Cycles of Abrasion[1]		Drapability[2]
First sign of Wear	Hole	in mm
150.0	286.0	0
240.0	610.0	21.35

[1]Ave. of 3 determinations
[2]Ave. of 3 determinations

Friction

One sample each for the friction test of both the satin and tricot were cut with the longer dimension in the direction of the warp, the filling, and bias of the cloth. Each of the slip fabrics were tested against both warp and filling of the following fabrics: velveteen, corduroy, and orlon pile fabrics; rayon, silk and wool crepe; flannelette, wool flannel, and wool tweed; rayon, wool, cotton warp knits; and sateen and rayon satin.

The face of the nylon satin and tricot knit were placed against the back of the different fabrics as would occur in wear. The greatest friction occurred in both warp and filling of the fourteen fabrics considered when tested against the filling of either the tricot or satin. Lowest friction was evidenced in both the warp and filling determinations of these fabrics when tested against the warp of either the tricot or satin. Test results showed the friction values for the bias strips fell between high and low values recorded for the warp and the filling.

When tested against the crosswise direction of the tricot friction drag from high to low ranked as follows: napped fabrics, crepe weaves, pile fabrics, knitted constructions, and satin weaves. When tested against the filling of the nylon satin, ranking was the same except for a reversal in the ranking of the knitted and satin weave groups. Rankings were similar for the nylon satin and nylon tricot.

TABLE IV

Coefficient of Kinetic Friction*

		Tricot			Satin		
		Warp	Filling	Bias	Warp	Filling	Bias
Velveteen	warp	.39	.58	.43	.26	.47	.397
	filling	.393	.477	.38	.26	.49	.39
Corduroy	warp	.393	.53	.41	.28	.49	.403
	filling	.38	.60	.43	.27	.52	.403
Orlon	warp	.21	.52	.23	.18	.56	.26
	filling	.32	.24	.25	.25	.21	.217
Rayon Crepe	warp	.39	.55	.42	.22	.44	.354
	filling	.41	.61	.42	,22	.43	.402
Silk Crepe	warp	.30	.33	.28	.24	.28	.29
	filling	.217	.71	.26	.18	.676	.343
Wool Crepe	warp	.33	.45	.38	.25	.53	.393
	filling	.313	.51	.383	.257	.493	.393
Cotton Flannel	warp	.37	.477	.40	.26	.42	.397
	filling	.36	.51	.39	.26	.42	.407
Wool Flannel	warp	.423	.623	.45	.25	.58	.417
	filling	.46	.62	.46	.25	.56	.407
Wool Tweed	warp	.433	.603	.46	.26	.51	.403
	filling	.443	.59	.46	.25	.523	.403
Rayon Knit	warp	.21	.393	.267	.17	.20	.34
	filling	.293	.19	.27	.17	.39	.26
Wool Knit	warp	.33	.483	.35	.21	.45	.32
	filling	.33	.45	.34	.21	.423	.317
Cotton Knit	warp	.46	.597	.427	.29	.527	.433
	filling	.437	.587	.427	.293	.62	.463
Cotton Sateen	warp	.40	.577	.40	.24	.59	.427
	filling	.40	.553	.42	.31	.57	.47
Rayon Satin	warp	.187	.30	.193	.15	.337	.233
	filling	.193	.23	.18	.157	.333	.21

*Average of 3 determinations

In all cases filling friction values were higher than warp values; bias values falling between. These tests substantiate the desirability of slips cut on the warp because there is less friction encountered than against the bias or crosswise grain. This suggests that bunching and sticking of the slip under different types of garments is due to the friction encountered. Variation in bunching et cetera is due to the weave construction of the two fabrics coming in contact with each other rather than to their fiber content.

C. ANALYSIS OF FABRICS AFTER LAUNDERING

Yarn Count

Changes in yarn count were less than two per cent throughout the laundering procedures. In hand-laundering the warp yarn count decreased slightly throughout the first ten launderings to 1.8 per cent or five yarns. The filling showed progressive increase with a terminal gain of 1.7 per cent.

More erratic changes occurred in machine-laundry than in hand-laundry. During the first ten launderings the warp count decreased whereas the filling increased. During the next twenty five launderings the warp increased. Terminal count for the warp was 1.3 per cent higher than the original. Filling count remained practically the same as the original.

TABLE V

Yarn Count*
Satin

No. L	Method of Laundry	Warp Number Per Inch	Warp % Ch	Filling Number Per Inch	Filling % Ch
0					
	Hand	293.0		129.4	
	Machine	293.0		129.4	
10					
	Hand	292.5	-.171	130.0	+ .46
	Machine	289.2	-1.30	130.0	+ .46
35					
	Hand	298.4	+1.84	131.6	+ 1.70
	Machine	296.8	+1.30	129.6	+ .15

*Average of 5 determinations

Course Count

In both methods of laundering, the tricot increased in wale and course count. This increase may be accounted for, in part, by its two to three per cent horizontal shrinkage. Maximum shrinkage occurred in the first ten launderings with slight change in the remaining twenty five. Terminal increase for both wale and course count was 3.3 per cent in hand-laundry. In the machine-laundry procedure increase was six per cent in wale count and five per cent in course count. The ratio of wales to courses was practically unchanged by either method of laundering. The increased count in the machine-laundered tricot cannot be explained on a basis of shrinkage for they shrank less than the hand-laundered slips. Area change by either method was slight and not apparent insofar as general appearance and hand were concerned.

FIGURE I

Per Cent Change in Course Count

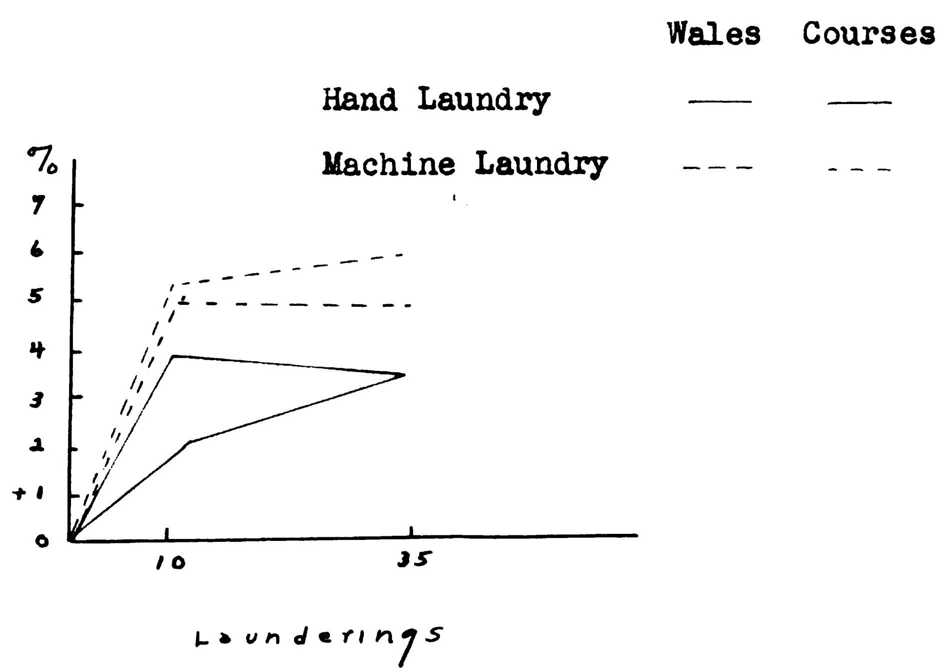


TABLE VI

Weight Per Square Yard
In Ounces and Per Cent Change

No. L	Method of Laundry	Satin oz. sq. yd.	Satin % Ch	Tricot oz. sq. yd.	Tricot % Ch
0					
	Hand	2.4999		2.35	
	Machine	2.4999		2.35	
5					
	Hand	2.4729	-1.08	2.50	+ 6.43
	Machine	2.4939	- .24	2.48	+ 5.24
10					
	Hand	2.475	- .96	2.51	+ 6.76
	Machine	2.4832	- .668	2.52	+ 7.08
15					
	Hand	2.4555	-1.78	2.49	+ 6.01
	Machine	2.4795	- .816	2.48	+ 5.47
20					
	Hand	2.4821	- .71	2.52	+ 7.05
	Machine	2.5252	+ 1.012	2.51	+ 6.52
25					
	Hand	2.4921	- .31	2.57	+ 9.15
	Machine	2.5049	+ .200	2.53	+ 7.38
30					
	Hand	2.4519	-1.92	2.59	+ 10.23
	Machine	2.5156	+ .628	2.54	+ 8.09
35					
	Hand	2.4699	-1.20	2.59	+ 9.98
	Machine	2.5535	+ 2.144	2.56	+ 9.02

Average of 5 determinations

Weight Per Square Yard

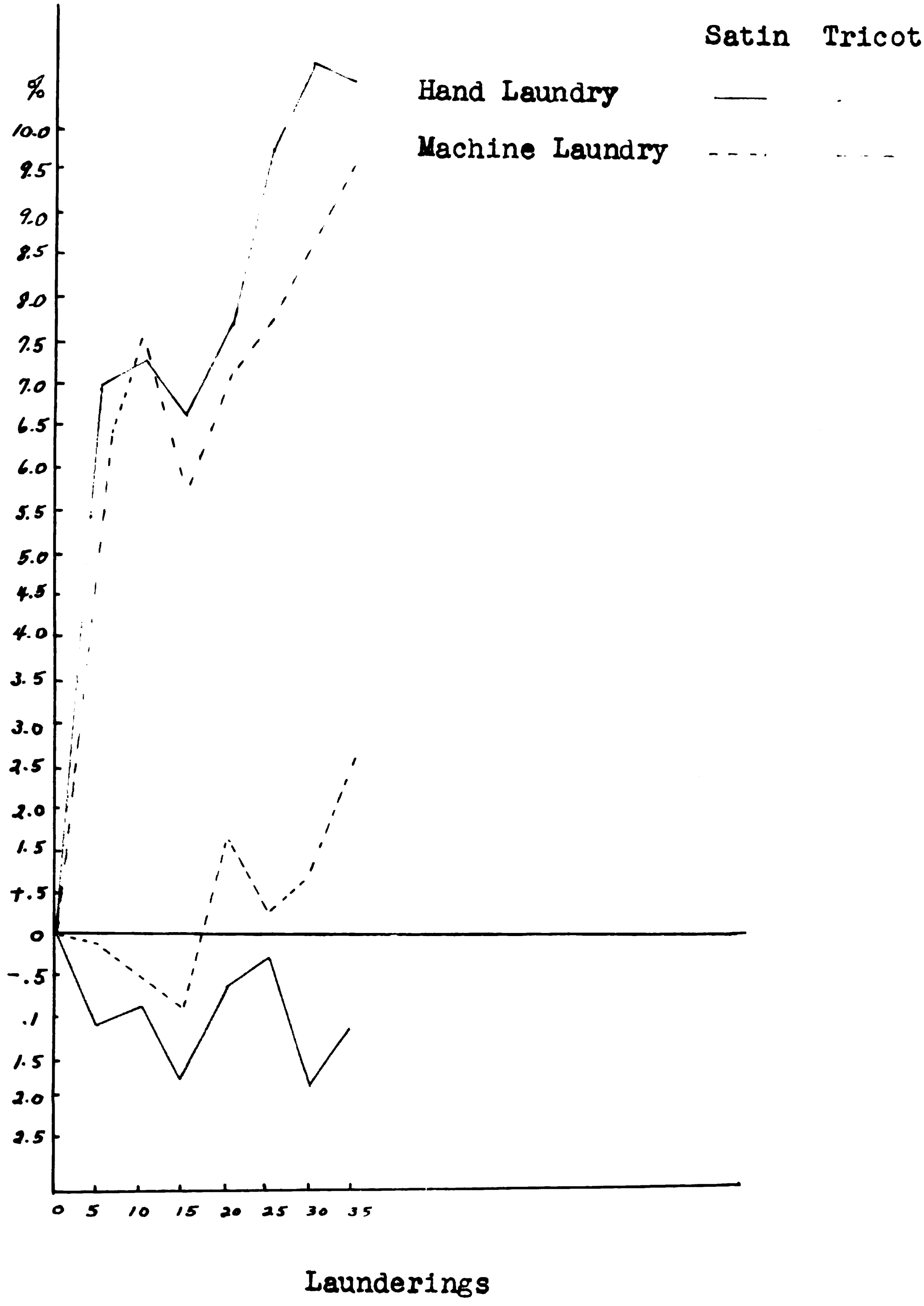
By either method of laundering, the tricot gained weight progressively. The hand-laundered tricot showed slightly greater gain than the machine-laundered. This might be expected inasmuch as the shrinkage in the hand-laundered garments was slightly greater. Greatest change took place in the first ten launderings. Terminal weight gain was ten per cent for the hand-laundered knit slips and nine per cent for the machine-laundered tricot slips. This gain in weight correlates with the gain in thickness.

Erratic weight changes were noted in the satin fabrics although it was less than two per cent throughout the series of launderings. This fabric followed the same pattern of weight change in both laundering methods for the first twenty launderings. The satin decreased in weight in the first fifteen launderings. Thereafter the satin showed a gain in weight when machine-laundered and loss of weight when hand-laundered. Terminal change, however, was only two per cent increase in machine-laundering and one per cent decrease in the hand-laundry procedure.

Weight change by either laundry method was slight for the satin but was five times greater for the tricot. However, even this ten per cent increase did not appreciably affect the appearance or body of the fabric.

FIGURE II

Weight in Per Cent Change



Thickness

Original thickness measurements, showed the tricot to be approximately forty per cent thicker than the satin.

Either laundry method resulted in gain in thickness for the tricot; this gain occurring in the first ten launderings, with no change in subsequent launderings. Thickness gain in the hand-laundry procedure was approximately three times greater than in the machine-laundry method. Terminal increase was seven per cent in hand-launderings and two per cent in machine launderings. This increase in thickness undoubtedly resulted from greater shrinkage which occurred in the hand-laundry method.

The satin also evidenced thickness gain in hand-laundry, Greatest change likewise took place in the first ten launderings with no change thereafter; with a terminal decrease in thickness of fifteen per cent. The machine-laundered satin slips lost approximately four per cent in thickness in the last twenty five launderings. The tricot, by both methods of laundry; and the hand-laundered satin showed no change after the first ten launderings.

It would have been expected that the fabric showing highest gain would also have shown greater shrinkage but this was not true in the case of either fabric. The nylon satin increased more in thickness than the tricot which had three times as much shrinkage. The laundering method seemingly affected thickness change inasmuch as thickness increase in the satin was twice that of the tricot in the hand-laundered method and six times greater than the tricot which was machine-laundered.

TABLE VII

Thickness in Inches and Per Cent Change*

No.	Method of Laundry	Tricot Std. Thickness	Tricot % Change	Satin Std. Thickness	Satin % Change
0					
	Hand	.0103		.0061	
	Machine	.0103		.0061	
10					
	Hand	.0110	6.80	.0070	+14.75
	Machine	.0105	1.94	.0071	+16.39
35					
	Hand	.0110	6.80	.0070	+14.75
	Machine	.0105	1.94	.0068	+11.47

*Average of 5 determinations

Color Change

In order to determine the degree of whiteness of the original nylon satin and tricot the disk colorimeter method was used. The color measurement was recorded in terms of the per cent amount of whiteness. The original satin fabric rated ninety five per cent whiteness on the color wheels. After the first five launderings, there was a seven per cent decrease in whiteness in the hand-laundered slips and nine per cent decrease in the machine-laundered. There was no further color change by either method in the subsequent fifteen launderings. After the twentieth laundering, an additional decrease in whiteness of one per cent was noted for the hand-laundered satin. The hand-laundered satin, at the termination of the study, had lost eight per cent in whiteness. The machine-laundered satin lost seven per cent so change in color was similar by either method of laundering for the satin.

The tricot fabrics had an eighty six per cent whiteness rating, or nine per cent lower than the satin. In the first five hand-launderings three per cent loss in whiteness was noted. After twenty five launderings, loss was four per cent but thereafter the degree of whiteness increased so that at the termination of the study the tricot was only two per cent more greyed than when new. The tricot in the machine-laundry procedure lost five per cent of its whiteness in the first five launderings, with erratic change at subsequent laundering intervals. Terminal loss was the same as that after only five launderings.

The tricot knit fabrics retained their original whiteness better when laundered by hand than by machine.

FIGURE III

Per Cent Whiteness on Color Wheel

Satin

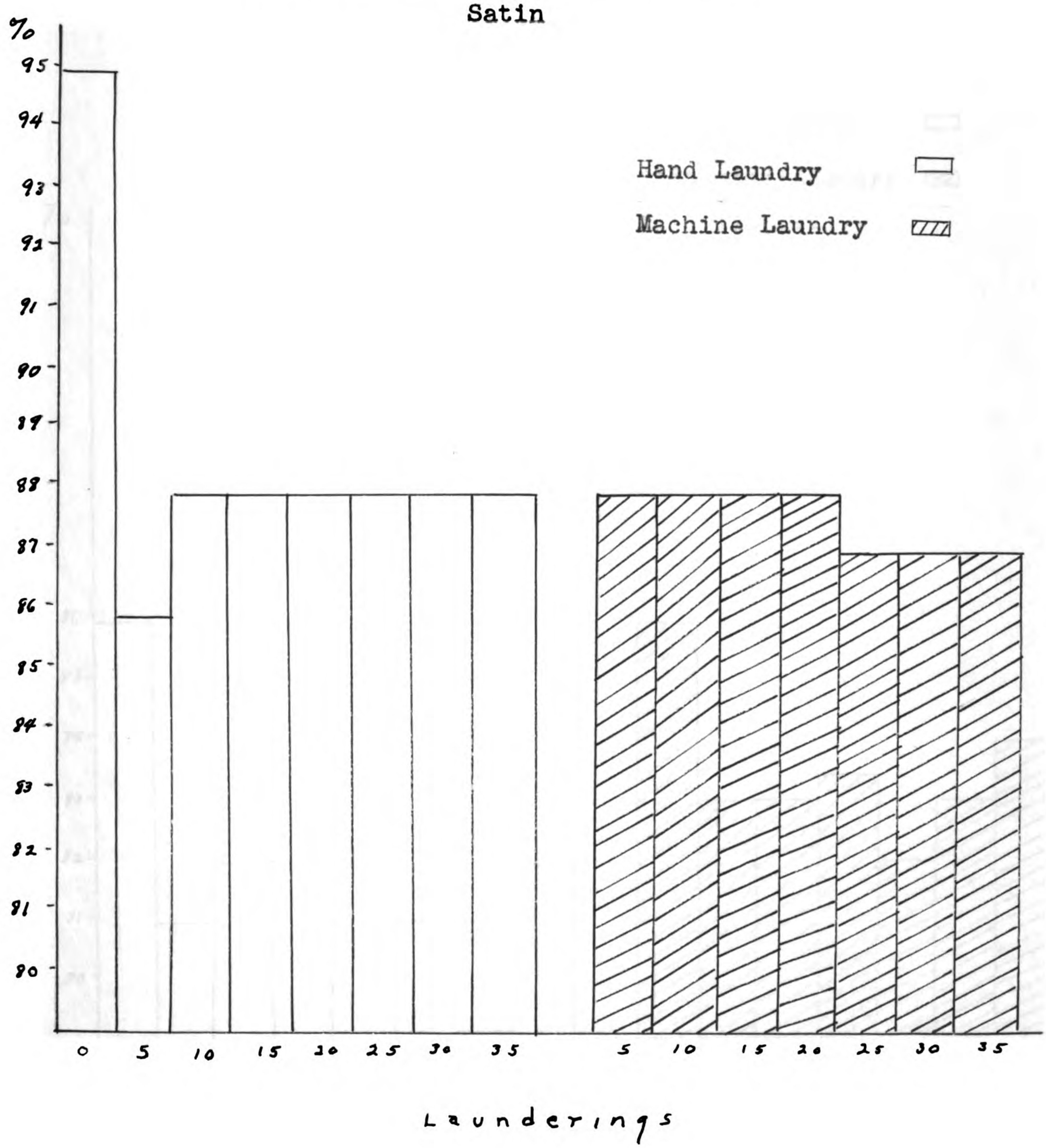
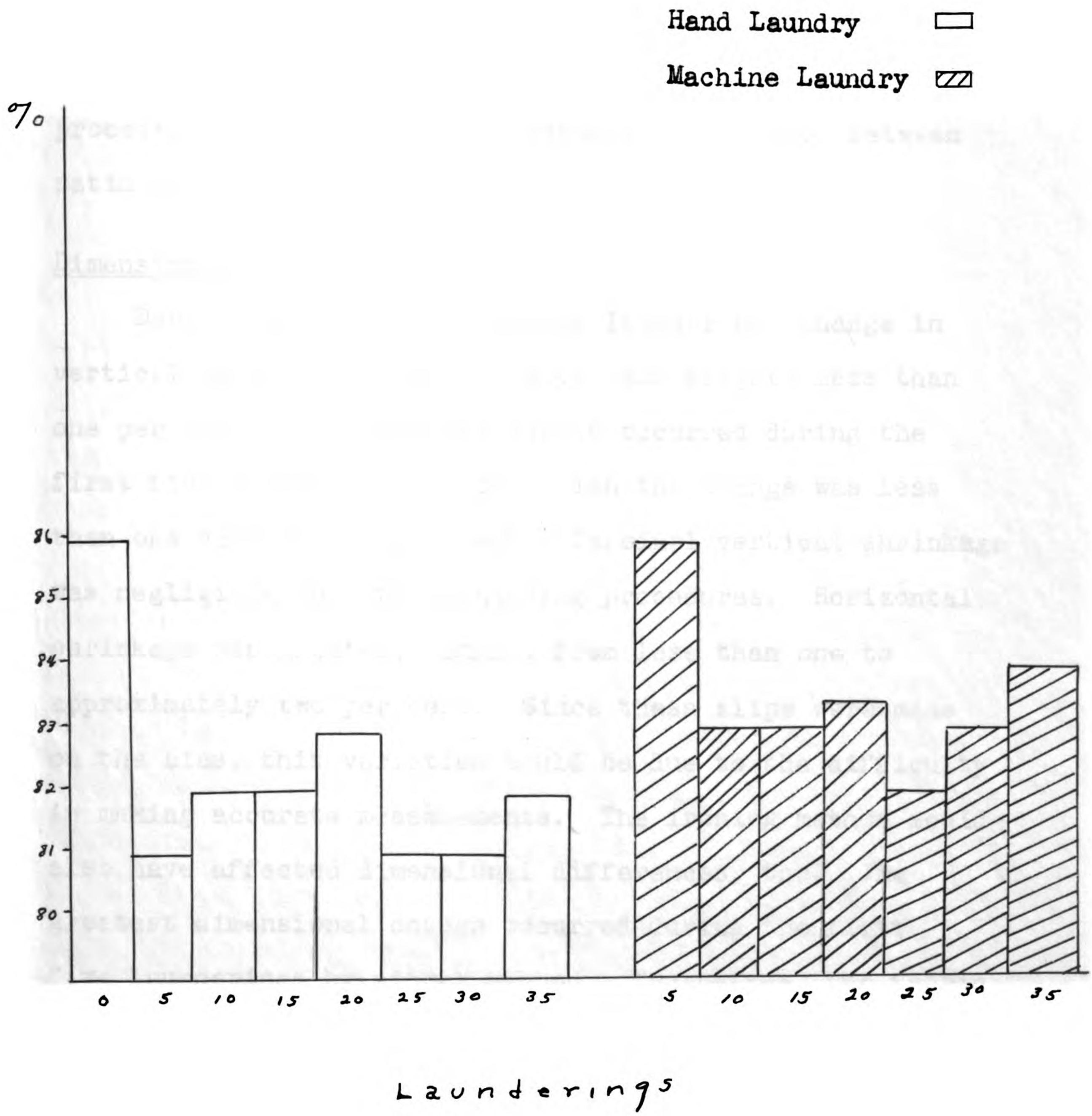


FIGURE IV

Per Cent Whiteness on Color Wheel

Tricot



In the case of the satin slips the method of laundry made no appreciable difference in the extent of change. The change in color in the first five launderings of the satin, may be due to loss of dye which had been used in finishing the fabric. The lower whiteness of the tricot may be due to the fact that it had not been dyed in the finishing process, or to the light reflectance differences between satin and knit constructions.

Dimensional Change

During both hand and machine laundering, change in vertical measurements of the satin was slight; less than one per cent. The greatest change occurred during the first five launderings, after which the change was less than one half of one per cent. Terminal vertical shrinkage was negligible in both laundering procedures. Horizontal shrinkage was greater; ranging from less than one to approximately two per cent. Since these slips were made on the bias, this variation could be due to the difficulty in making accurate measurements. The ironing method could also have affected dimensional differences, too. The greatest dimensional change occurred during the first five launderings by either method. Thereafter, the fabric stretched slightly. However, the terminal shrinkage was only one per cent in hand-laundering and approximately the same in machine-laundering. This amount of shrinkage would not be considered objectionable.

Vertical shrinkage in the tricot was similar to that in the satin. Shrinkage was less than one per cent throughout the series of thirty five launderings for either method. Greatest change occurred in the first five launderings but terminal vertical shrinkage was negligible by either method. In both laundering procedures the fabrics continued to shrink in width until the study was terminated. There was a total shrinkage in width of three and four tenths per cent by hand, and three per cent in machine-laundering. Inasmuch as there was almost negligible change in the last twenty five launderings by either method; it would indicate that in any further launderings they would not show appreciable change. Rann (20) found that the acetate satin shrank widthwise two and one half per cent in the first laundering and a total of five per cent after twenty launderings. However, the lengthwise measurements showed three per cent stretchage after twenty launderings. In the nylon satin it was found that greatest shrinkage occurred in the first five launderings but total lengthwise shrinkage was negligible even after thirty five launderings by either hand or machine method.

Bayor (3) found that the two-bar rayon tricot slips shrank a total of over eight per cent widthwise when dried flat or on a rod. The average linear shrinkage after twenty launderings was five per cent when dried flat and three per cent when dried over a rod. The rayon slips that were dried flat had decided dips at the underarm seams and a rise in both the center front and back sections. The slips dried on the rod were obviously longer, this being due to stretchage which resulted from the natural action of the weight of the slip on itself.

The slips made of acetate shrank nineteen per cent in width when dried flat and over a rod. In the linear measurements there was one per cent stretchage when dried flat and five tenths per cent stretchage when dried over a rod. The acetate slips hung more evenly than the rayon in spite of the large percentage of widthwise shrinkage.

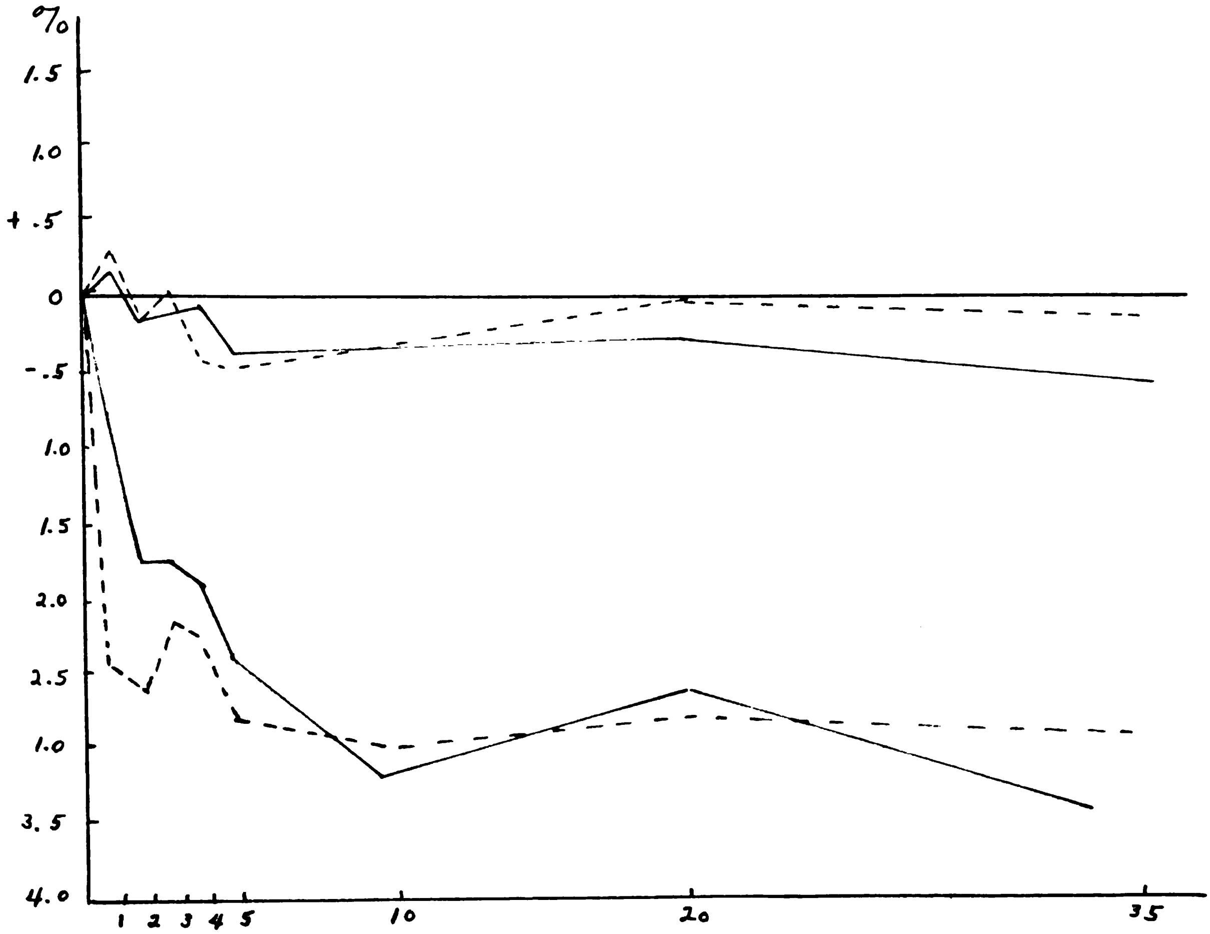
In contrast to the acetate and viscose, the nylon in this study had a three per cent shrinkage in the width measurements and a negligible amount lengthwise. The dimensional change in the nylon slips seemed to be consistent throughout the garment which resulted in a more even hem line than was evidenced in the rayon and acetate.

FIGURE V

Average Per Cent Dimensional Change

Tricot

	Vertical	Horizontal
Hand Laundry	———	-·—·-
Machine Laundry	- - - -	- - - -



Launderings

FIGURE VI

Average Per Cent Dimensional Change

Satin

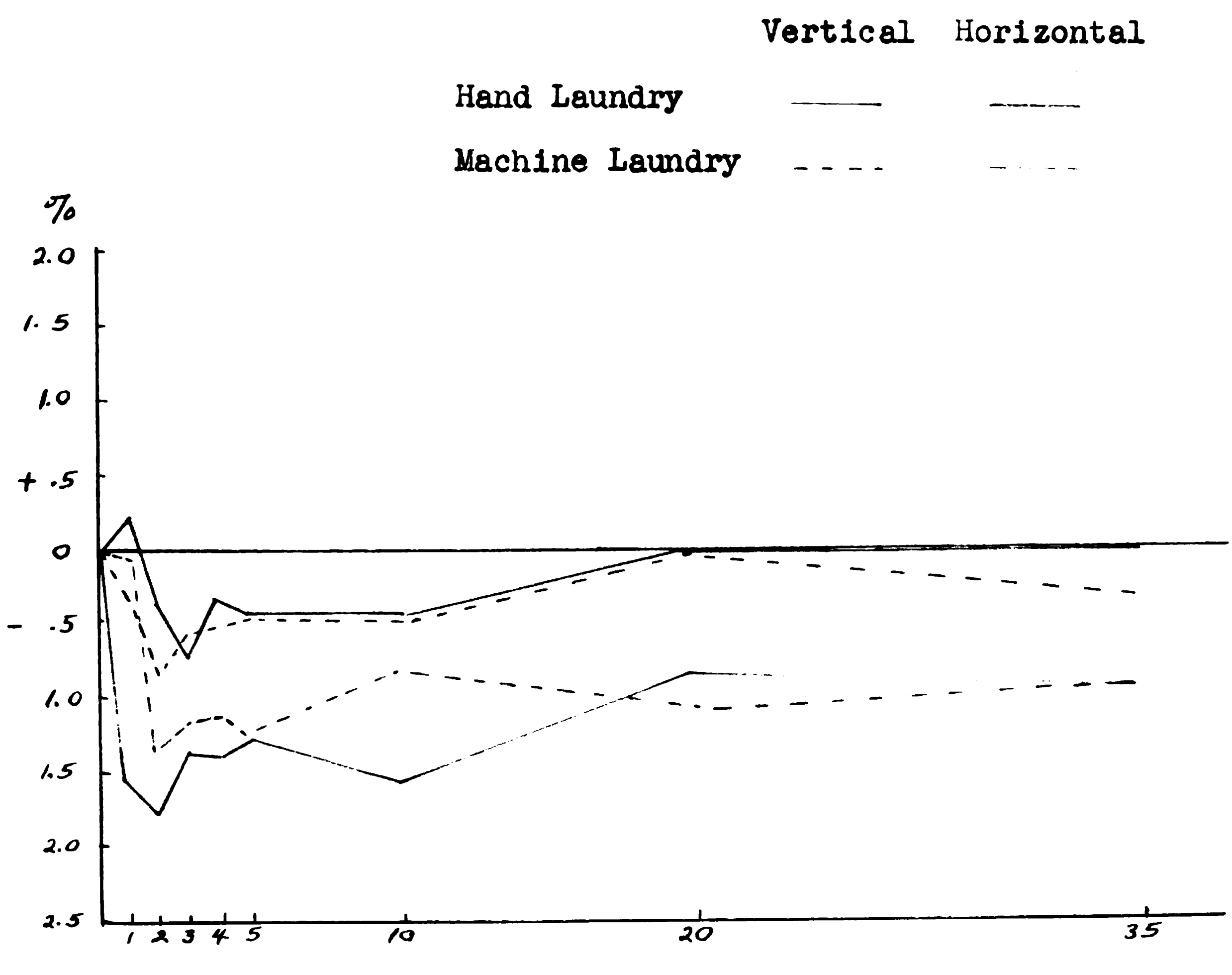


TABLE VIII

Bursting Strength in
Pounds and Per Cent Change*

Tricot

No. of	Hand Laundry				Machine Laundry			
Laundry	Dry	% Ch	Wet	% Ch	Dry	% Ch	Wet	% Ch
0	103.4		88.4		103.4		88.4	
10	94.4	- 8.7	91.6	+ 3.6	95.0	- 8.1	87.2	- 1.4
35	75.6	-26.9	66.4	-24.9	81.4	-21.3	76.8	-13.1

*Average of 5 determinations

Bursting Strength

There was progressive decrease in dry bursting strength in either method of laundry. At withdrawal intervals, decrease was somewhat greater in the hand-laundered which is inconsistent with their higher shrinkage. At the termination of the study, dry bursting strength loss was twenty seven per cent by the hand-laundered procedure and twenty one per cent by machine-laundering. Wet bursting strength showed progressive decrease in strength when laundered in the machine; from one per cent in ten launderings but a terminal loss of thirteen per cent. In the hand-laundered procedure, there was a gain of more than three and one half per cent in ten launderings, but a terminal loss of twenty five per cent. Thus dry strength loss, by either method was higher than wet strength loss. Both wet and dry strength loss was greater in hand-laundering than in machine. However, at the termination of the study wet strength was eighty eight per cent of the dry in the hand-laundering method and ninety-five per cent in the machine-laundered. This falls within the usual dry-wet ratio for nylon.

Bayor (3) found that acetate tricot had about one-third of its dry strength when wet; and rayon less than half of its dry strength. It is interesting to note that the original dry bursting strength of the acetate tricot in Bayor's study was twenty nine and one half pounds and wet strength, twenty two pounds. The rayon knit strength was about forty four pounds with wet strength of twenty two pounds as contrasted to the nylon tricot in this study which burst at one hundred and three pounds when dry; and eighty eight pounds when wet. In the rayon and acetate the bursting strength increased slightly in laundering while the nylon in this study showed decrease in bursting strength. This is accounted for by the much greater shrinkage in the rayon and acetate tricot.

Breaking Strength

Both wet and dry breaking strength in the warp of the original satin fabrics were more than twice that of their filling strengths.

Warp and filling dry strengths increased progressively during the thirty five hand-launderings, to a terminal increase of forty five and thirty two per cent respectively for warp and filling. The machine-laundered samples showed increased dry strength during the first ten launderings for both warp and filling. In subsequent launderings, warp strength continued to increase while filling strength decreased. Terminal strength values for the warp were fifty one per cent higher than the original; fifteen per cent higher in the filling. Increase in dry warp strength was greater than filling strength increase, by either method of laundry.

During the first ten launderings, there was increased wet breaking strength for both warp and filling in both laundering procedures. In the hand-laundered garments, filling strength continued to increase while warp strength decreased. However, in the fifteen subsequent machine-launderings, there was a reversal, the warp strength increasing and the filling strength decreasing sharply. Terminal wet strength increase was greater warpwise than in the direction of the filling in both laundering procedures. However, warp increase was slightly greater in the machine-laundered. The warp-filling ratio in strength was approximately the same for the new fabric as after thirty five hand-launderings. Warp strength gains of the machine-laundered was approximately three times greater than filling gain at the termination of the study; a three to one strength ratio.

According to Rann's (20) study, the acetate satin had a dry warp breaking strength of twenty four pounds, and thirty three pounds in the filling. Warp wet breaking strength was approximately ten pounds and filling strength eleven pounds. The significantly lower wet strengths in both the acetate and rayon satins substantiates the predictive durability of the nylon satin as far superior to either acetate or rayon.

FIGURE VII

Breaking Strength
In Per Cent Change

Satin

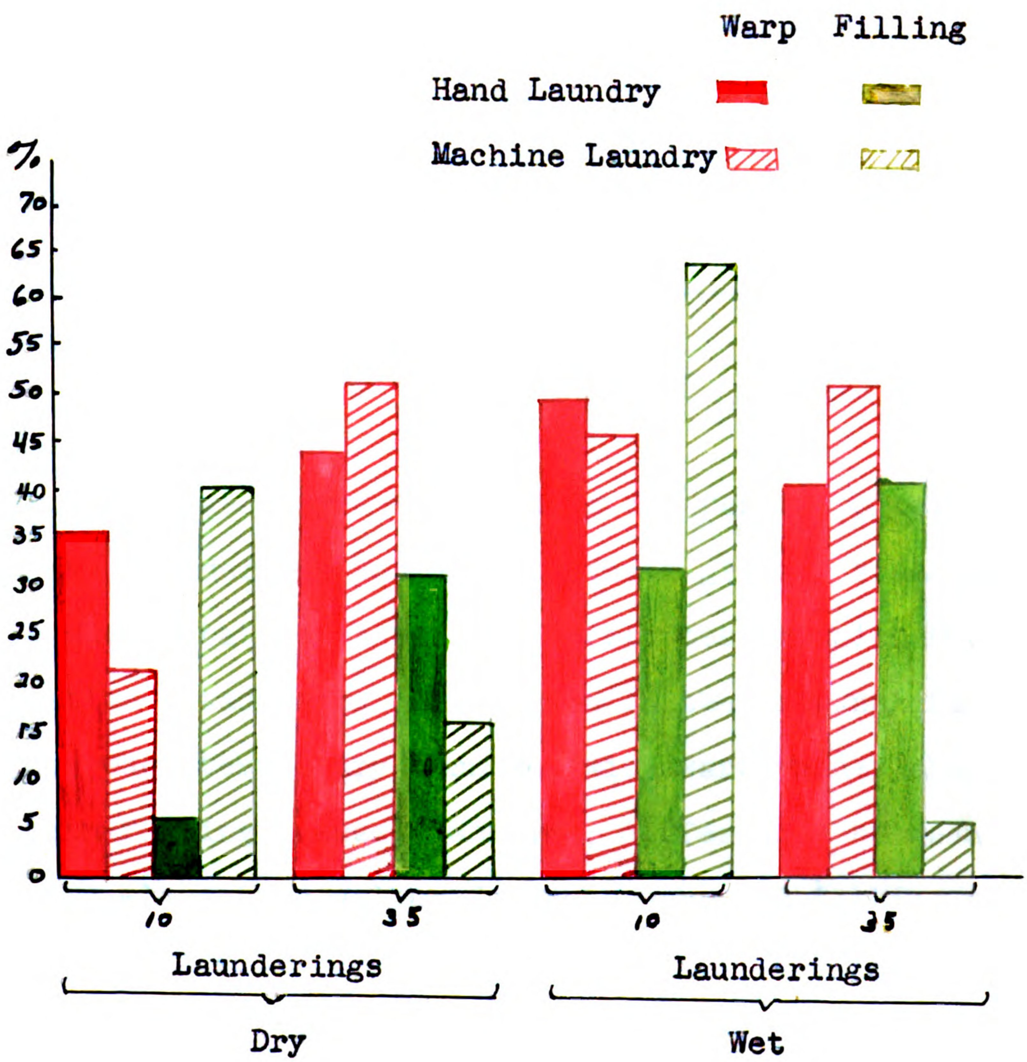


TABLE IX

Breaking Strength in
Pounds and Per Cent Change*

Satin

No. L		Hand Laundry Warp	% Ch	Filling	% Ch	Machine Laundry Warp	% Ch	Filling	% Ch
0	Dry	71.8		30.9		71.8		30.9	
	Wet	55.6		23.8		55.6		23.8	
10									
	Dry	97.9	+ 36.5	32.6	+ 5.7	87.5	+ 21.9	43.6	+ 41.3
	Wet	83.4	+ 50.0	31.8	+ 33.6	81.4	+ 46.4	39.0	+ 64.1
35									
	Dry	103.9	+ 44.7	40.8	+ 32.0	108.7	+ 51.4	35.7	+ 15.5
	Wet	78.5	+ 41.2	33.5	+ 40.8	84.6	+ 52.2	25.1	+ 5.5

*Average of 10 determinations

Elongation

Elongation was not determined on the fabrics after thirty five launderings inasmuch as their greater breaking strength necessitated the use of a Scott tester which had no elongation attachment. Elongation in the original fabrics was higher when tested dry than wet with warp values slightly higher than filling values. However, differences between wet and dry elongation values for both warp and filling were under three per cent. In the hand-laundry procedure there was an increase of thirty nine per cent in dry elongation in the warp and nine per cent in the filling. Wet elongation per cent increase in the warp was fifty one per cent and twenty seven for the filling. Conversely, both wet and dry warp elongation decreased in machine-laundering with greatest loss in dry elongation. Filling elongation increased in both wet and dry tests; wet elongation being greater than dry. Change in elongation resulting from laundering, widened the difference between wet and dry determination for both warp and filling. After thirty five hand-launderings the garments had approximately ten per cent higher warp than filling elongation. The reverse was true in the machine-laundered fabrics.

TABLE X

Elongation in Per Cent*

Satin

No.		Hand Laundry				Machine Laundry			
L		Warp	% Ch	Filling	% Ch	Warp	% Ch	Filling	% Ch
0	Dry	23.5		21.8		23.5		21.8	
	Wet	20.73		18.6		20.7		18.6	
10									
	Dry	32.6	+ 39.0	23.7	+ 8.7	20.6	-12.3	30.4	+ 39.5
	Wet	31.4	+ 51.5	23.7	+ 27.4	19.8	- 4.4	30.0	+ 61.2

*Average of 10 determinations

Abrasion

In hand-laundering, the tricot evidenced increased abrasion resistance resulting from the first ten launderings but was followed by a decrease in abrasion resistance in subsequent launderings. After ten launderings there was an increase in wear cycles of fifteen per cent for the first sign of wear and fifty per cent to the first hole. However, in the twenty five launderings which followed there was a significant decrease (+15 to +5) for first sign of wear; from (+50 to -5) for evidence of a hole.

Decrease in abrasion resistance in the machine-washed tricot was not as great in the first ten or in subsequent launderings as decrease in the hand-laundered tricot slips. In the last twenty five machine-launderings abrasion resistance was three per cent greater for first sign of wear than on the new fabric. This increased abrasion resistance parallels the shrinkage which occurred in the tricot. (See Plate XI, XII, pp. 84, 85)

The satin slips decreased two per cent in their abrasion resistance for first sign of wear but increased twenty nine per cent for breakdown in the first ten hand-launderings. However, in subsequent launderings, there was a decrease in wear cycles necessary for either the first sign of wear or hole. The resultant terminal loss in abrasion resistance in the satin was fifteen per cent to first sign of wear and six per cent to the first appearance of a hole. (See Plate IX, X, pp. 82, 83)

By the machine-laundry procedure the greatest decrease in abrasion resistance occurred in the first ten launderings, with only three per cent change thereafter. Terminal decrease in abrasion resistance was thirty per cent for first sign of wear and eleven per cent to the first hole for the satin fabric.

The hand-laundering procedure showed more decrease in abrasion resistance in the tricot, but the machine-laundering caused a greater decrease in the satin. However, there was an insufficient number of determinations to justify any valid conclusions.

TABLE XI

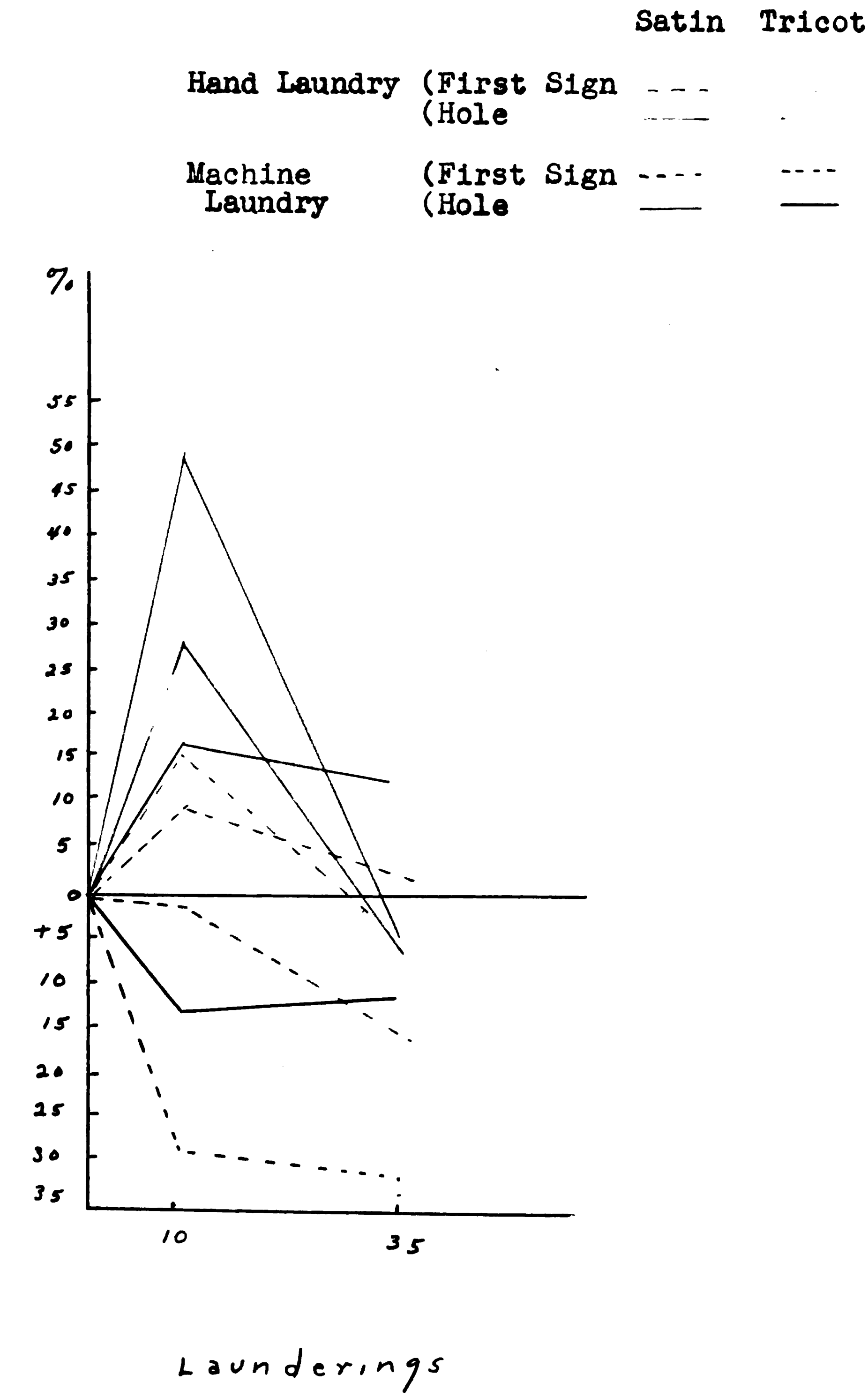
Abrasion

Method of Laundry		Tricot				Satin			
		1st Sign Wear		Hole		1st Sign Wear		Hole	
		% Ch	Cycles	% Ch	Cycles	% Ch	Cycles	% Ch	Cycles
Hand	0		150.0		286.0		240.0		610.00
	10	+15.8	173.7	+50.46	430.33	- 1.79	235.7	+28.69	785.00
	35	- 5.33	142.0	- 5.35	270.70	-15.42	203.0	- 5.79	574.00
Machine	0		150.0		286.0		240.0		610.00
	10	+ 9.55	164.33	+16.08	332.0	-27.21	174.7	-13.77	526.00
	35	+ 2.67	154.00	+13.39	324.3	-30.29	167.3	-10.61	545.3

*Average of 3 determinations

FIGURE VIII

Abrasion In Per Cent Change



Drapability

The drapability of the tricot fabric was unchanged in either method of laundering, remaining at the zero reading.

Drapability decreased in the satin fabric, slightly in hand and appreciably in machine laundering. Terminal change was four per cent in hand-laundering but fifty two per cent in machine-laundering. This significant decrease in drapability in the last twenty five machine-launderings may be due to the fact that early loss of soluble finish and weight loss in the first ten launderings; apparently minimized or counteracted the effects of gradual fulling which characterized the behavior change in the satin in the less rigorous hand-laundering method. Shrinkage determinations are questionable because of the bias cut of the garments; it is quite possible that shrinkage was actually greater than the data indicated.

TABLE XII

Drapability*

Satin

		Geom. Mean	% Change
0		21.35	
10			
	Hand	22.61	+ 5.90
	Machine	23.78	+11.38
35			
	Hand	22.28	+ 4.36
	Machine	32.51	+52.27

*Average of 3 determinations

V. CONCLUSIONS

Analysis of the laboratory test data on the white nylon slips in this study before and after laundering, indicate that either the hand or machine-laundering procedure was satisfactory for washing both the white nylon tricot and satin slips since there was no significant difference in fabric performance in the two methods. On the basis of the findings in this study one method of laundry could not be recommended as better than the other. This may have been due, in part, to the controlled method of hand-laundering followed. However, the average person would probably obtain better results, particularly in respect to discoloration; in machine-laundering than in hand-laundering since the amount and temperature of the water, more effective scouring and thorough rinsing, would be given in machine-laundering than is usually practiced in hand laundering in the home.

Since color change was not significant in either fabric in the last thirty launderings it would indicate that additional launderings would not result in appreciable additional greying or yellowing of the fabric. Either method of laundry used in this study seemed efficient in preventing a redeposition of soil which causes fabrics to appear soiled or greyed.

In general, maximum shrinkage occurred in the first five launderings and is substantiated by previous laundry studies. Shrinkage was greater in the tricot knit construction than in the woven satin. Horizontal shrinkage was greater than linear shrinkage but total shrinkage was not sufficiently great to materially affect the fit of either type of slip. Negligible shrinkage in the last fifteen launderings indicated that continued laundering would not result in appreciable dimensional change.

The fact that breaking strength increased in the satin in both methods of laundry while bursting strength decreased in the tricot cannot be satisfactorily explained. Because the wet strength of both the tricot and satin remained within the eighty to ninety per cent range of wet to dry strength it is evident that nylon has superior qualities of wet strength as well as dimensional stability when compared to either acetate or rayon knit or woven slips.

Although friction values were high in both the satin and tricot it was found that the weave of the fabric tested against the nylon caused greater variation in friction drag than fiber content so variation in behavior may be due in part, to the outer clothing, and in part to the cut of the slip. Nylon satin and tricot slips cut on the lengthwise grain, would cause less friction with outer clothing than those cut crosswise and somewhat less than the bias cut garments.

Because the satin slips showed somewhat less dimensional change, retention of strength and comparable abrasion resistance than the tricot their better performance in these factors of wear imply that they would give better total serviceability. However, differences were not significantly great to justify the conclusion that the satin slips had a higher wear potential. The greater porosity, excellent draping qualities and the satisfactory appearance of the tricot requiring no ironing, makes the tricot as desirable or perhaps more desirable than the nylon satin for many women.

Since this study was limited to laboratory analysis, the data cannot be considered adequate as a predictive measure of serviceability. For a truer evaluation of serviceability and satisfaction in use it would be desirable to carry on a wear study in conjunction with laboratory analysis since perspiration and body strain significantly affect fabric performance.

VI. SUMMARY

Six white nylon satin slips and six nylon tricot knit slips were used in this study for comparison of color and dimensional change resulting from thirty five hand and thirty five machine-launderings.

Comparison of dimensional and color change in the two types of slips was also made. Analysis and comparison of physical properties and performance characteristics of the new fabric with those same properties and characteristics after laundering constituted the criteria for prediction of their potential serviceability and behavior in use. The slips were given a modified standard dry soil treatment at each five laundering intervals and washed by home procedures with a synthetic detergent.

Initial specifications indicated the nylon satin and nylon tricot were not significantly different in weight but were unlike in thickness. The denier for the nylon satin slips was higher than that in the tricot; the filament count being approximately the same in both the warp and filling. The twist of the satin filling yarns was four times that of the twist in the warp yarns. Warp yarn count was two and one half times greater than filling count. Warp breaking strength in both wet and dry determinations was twice that of the filling. Wet breaking strength in the satin was eighty per cent of its dry strength. The tricot had twice as many wales as courses with wet bursting strength eighty five per cent of the dry.

When tested with a group of apparel fabrics of different constructions and fiber content, the coefficient of kinetic friction was comparable for both the satin and tricot. Both showed the highest friction values in the filling direction and lowest values in the direction of the warp.

In either hand or machine laundering, change in yarn count in the satin was negligible. The tricot increased slightly in course count which paralleled its shrinkage in either method of laundering. By either method of laundry weight change in the satin was slight. The tricot increased in weight progressively with the number of launderings; with terminal gain in weight five times that of the satin. However, the tricot was not appreciably affected in appearance, body, or hand.

Greatest dimensional change occurred during the first five hand or machine-launderings for both the satin and tricot slips. There was slight difference in the amount of shrinkage between the two methods of laundry. Shrinkage was greater in the tricot than the satin, with greater dimensional change in the horizontal measurements than linear measurements in both slips.

The tricot knit retained its original whiteness better in hand laundry than in machine, whereas the method of laundry made no appreciable difference in whiteness retention in the satin slips. The satin slips lost a higher percentage of their original whiteness than the tricot. Loss in bursting strength of the tricot was greater in hand-laundering than in machine-laundering. There was a greater per cent loss in dry strength than in wet by both laundering methods.

The wet bursting strength retained eighty eight to ninety five per cent of its dry strength in hand and machine-laundry respectively.

Abrasion resistance in the tricot increased after thirty five machine-launderings but decreased slightly in comparable hand-launderings. The satin fabric evidenced decreased resistance to abrasion in both methods of laundering; loss being twice as great in machine-laundry as laundering by hand.

LITERATURE CITED

LITERATURE CITED

1. Alexandra, F. J. and Sturley, C. H., "The Influence of Twist on the Breaking Load and Breaking Extension of Continuous Filament Nylon Yarns and Monofil," The Journal of the Textile Institute, Volume XXXIV, No. 1, January, 1952, pp. 1-18.

2. American Society for Testing Materials, Committee D-13 on Textile Materials, A.S.T.M. Standards on Textile Materials, The Society, Philadelphia, Pennsylvania, 1950.

3. Bayor, Stephania Eleanor, Comparison of Some Physical Properties Affecting Service Qualities of Three Brands of Rayon Warp Knit Slips, (Unpublished thesis, Michigan State College, 1946).

4. Campbell, Jerome, "What's New in Tricot," Modern Textiles, Vol. XXXIII, December, 1952, pp. 33-.

5. Campbell, J., "Progress in Nylon, Rayon, Vol. XXXIII, No. 9, September, 1952, p. 23.

6. "Care of Nylon Fabrics," Rayon, Vol. XXXI, April, 1950, p. 67.

7. Dreby, Edwin C., A Friction Meter for Determining the Coefficient of Kinetic Friction of Fabrics, Research Paper RP1562, Part of Journal of the National Bureau of Standards, Volume XXXI, October, 1943.

8. Fletcher, Hazel M., Duensing, Mary Ellen, and Gilliam, Jane F., "Dimensional Change of Knit Goods in Laundering," American Dyestuff Reporter, Vol. 38, No. 13, June 27, 1949, pp. 481-483-.

9. Fletcher, Hazel M. and Roberts, Helen S., "The Geometry of Knit Fabrics Made of Staple Rayon and Nylon and Its Relationships to Shrinkage in Laundering," Textile Research Journal, Vol. XXII, No. 7, July, 1952, pp. 466-471.

10. Fletcher, Hazel M. and Gilliam, "Abrasion Resistance of Four Rayon Fabrics Used in Women's Slips," Rayon and Synthetic Textiles, Vol. XXXI, July, 1950, pp. 39-40.

11. Furry, M. S., McLendon, Verda I. and Aler, Mary E., American Dyestuff Reporter, Vol. 37, November 15, 1948, reprint pp. 1-10.

12. "How to Safely Bleach Nylon and Rayon," Compliments of Gold Seal Co., Bismark, North Dakota, Man. of Snowy Bleach, Pamphlet.

13. Kroll, R. L. and Williams, K. R., "A Study of Nylon Tricot Snagging," Rayon, Vol. XXX, September, 1949, pp. 111-113.

14. Leonard, E. A., Schwarz, E. W. K., "Measurement of Fabric Soiling," American Dyestuff Reporter, Vol. XLI, May 26, 1952, pp. 322-340.

15. "Learn a Lesson from Nylon," Rayon, Vol. XXXII, June, 1951, pp. 35-37.

16. McKee, Barbara N. and Roseberry, Elizabeth D., "Soil Removal from Nylon, A Study of the Effects of Various Washing Conditions," Rayon and Synthetic Textiles, Vol. XXXII, May, 1951, pp. 62-64.

17. Mecklenburgh, G. K., "The Setting of Nylon Fabrics," Journal of the Textile Institute, Vol. XLI, No. 4, April, 1950, pp. 161-174.

18. Millard, F., "Nylon Staple on the Cotton System; Some Properties of All Nylon Yarn," Textile Institute Journal Transactions, Vol. XLII, April, 1951, pp. 168-180.

19. "New Chemical Compound When Added to Soaps and Synthetic Detergents Makes Brighter, Whiter Clothes," Chemistry and the Home, Issued by Extension Division, Public Relations Department, E. I. Du Pont De Nemours and Co., Wilmington 98, Delaware.

20. "Proper Care Means Longer Life for Nylon," Chemistry and the Home, Issued by Extension Division, Public Relations Department, E. I. Du Pont De Nemours and Co., Wilmington 98, Delaware.

21. Quig, J. B., "The Acceptance of Nylon by the Consumer," Rayon, Vol. XXXI, June, 1950, pp. 59-60.

22. Rann, Florence G., A Comparative Study of Four Brands of Women's Rayon Woven Slips of Comparable Price, (Unpublished thesis, Michigan State College, 1946).

23. Skinkle, John H., Textile Testing, Chemical Publishing Company, Brooklyn, New York, 1949.

24. Snell, Foster Dee, "Synthetic Detergents in the Textile Industry," Rayon and Synthetic Textiles, Vol. XXX, November, 1949, pp. 90-91.

25. ________________, "Soap and Detergents as Affecting Textiles," American Dyestuff Reporter, Vol. XXXII, No. 15, July 24, 1950, pp. 481-486.

26. ________________, "Soap and Detergents as Affecting Textiles," American Dyestuff Reporter, Vol. XXXIX, No. 15, July 24, 1950, pp. 481-483.

27. Suter, Alfred, "New Precision Twist Test and Universal Yarn Numbering Balance," Textile Engineer, New York.

28. "Synthetic Fibers," Chemical Engineering, Vol. LVIII, August, 1951, pp. 125-132.

29. Taber, Carl, "Nylon Fabric Development," Rayon, Vol. XXXI, May, 1950, pp. 87-89.

30. Taber, Abraser Model E- 4010 Instruction Manual, Taber Instrument Corporation, North Tonawanda, New York, 1945.

31. "Tensile Strength and Elongation of Nylon Yarns," Rayon, Vol. XXXXI, July, 1950, p. 64.

32. Thompson, Thelma Lucetta, A Study of the Reliability of Laboratory Tests in Measuring Serviceability of Rayon Slips, (Unpublished thesis, Michigan State College, 1947).

33. Weiner, Louis I., "Factors Affecting the Relaxation Shrinkage of Knit Underwear Tubing," American Dyestuff Reporter, Vol. XXXIX, No. 8, April 17, 1950.

34. Williams, Wyn A., "Tricot Comes Into Its Own," Rayon, Vol. XXXIII, No. 2, February, 1952, p. 35-.

APPENDIX

PLATE I

Satin •

After Hand Laundering	Original	After Machine Laundering
	5	
	10	
	15	
	20	
	25	
	30	
	35	

PLATE II

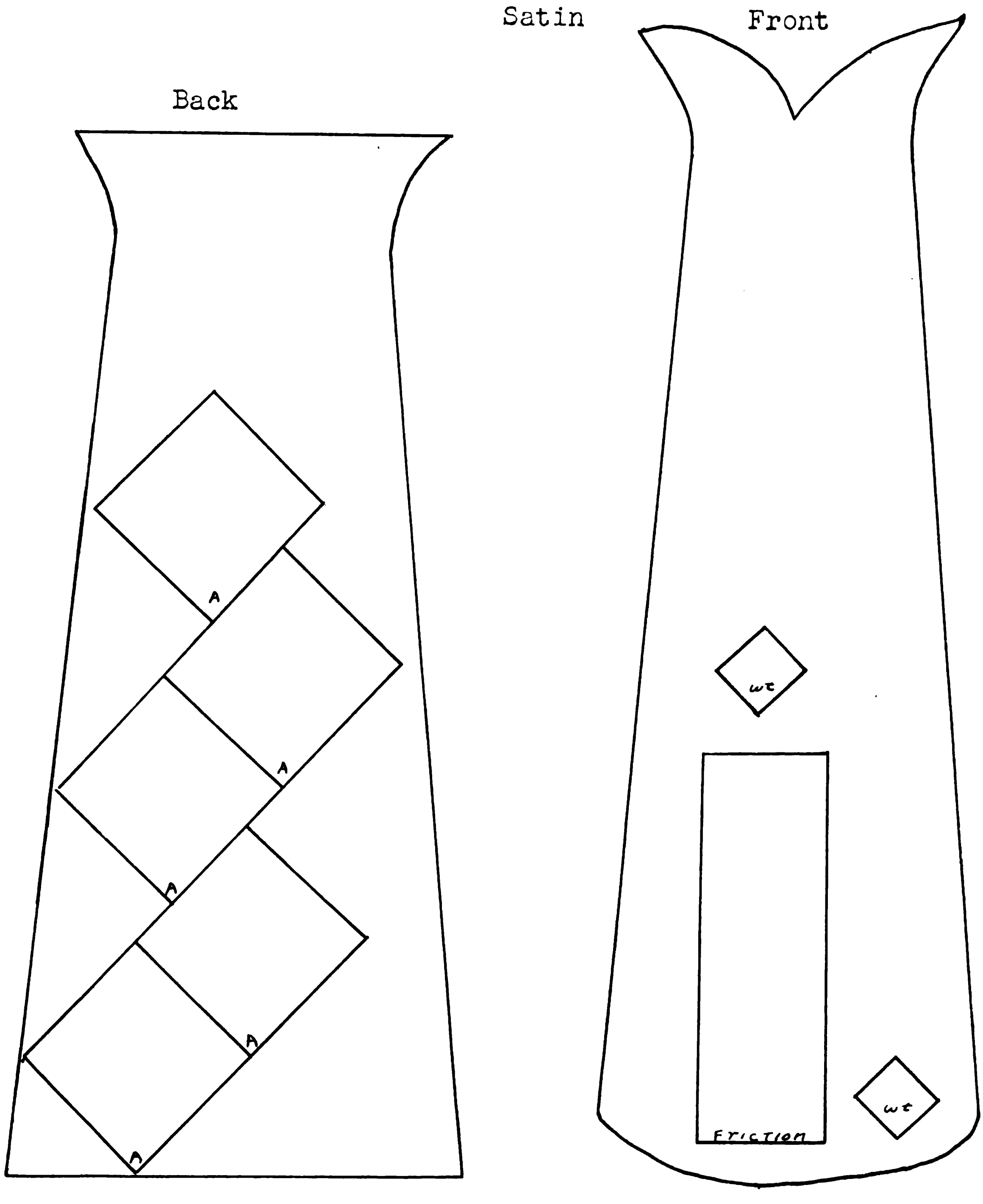
Tricot

After Hand Laundering	Original	After Machine Laundering
	5	
	10	
	15	
	20	
	25	
	30	
	35	

PLATE III

Cutting Chart

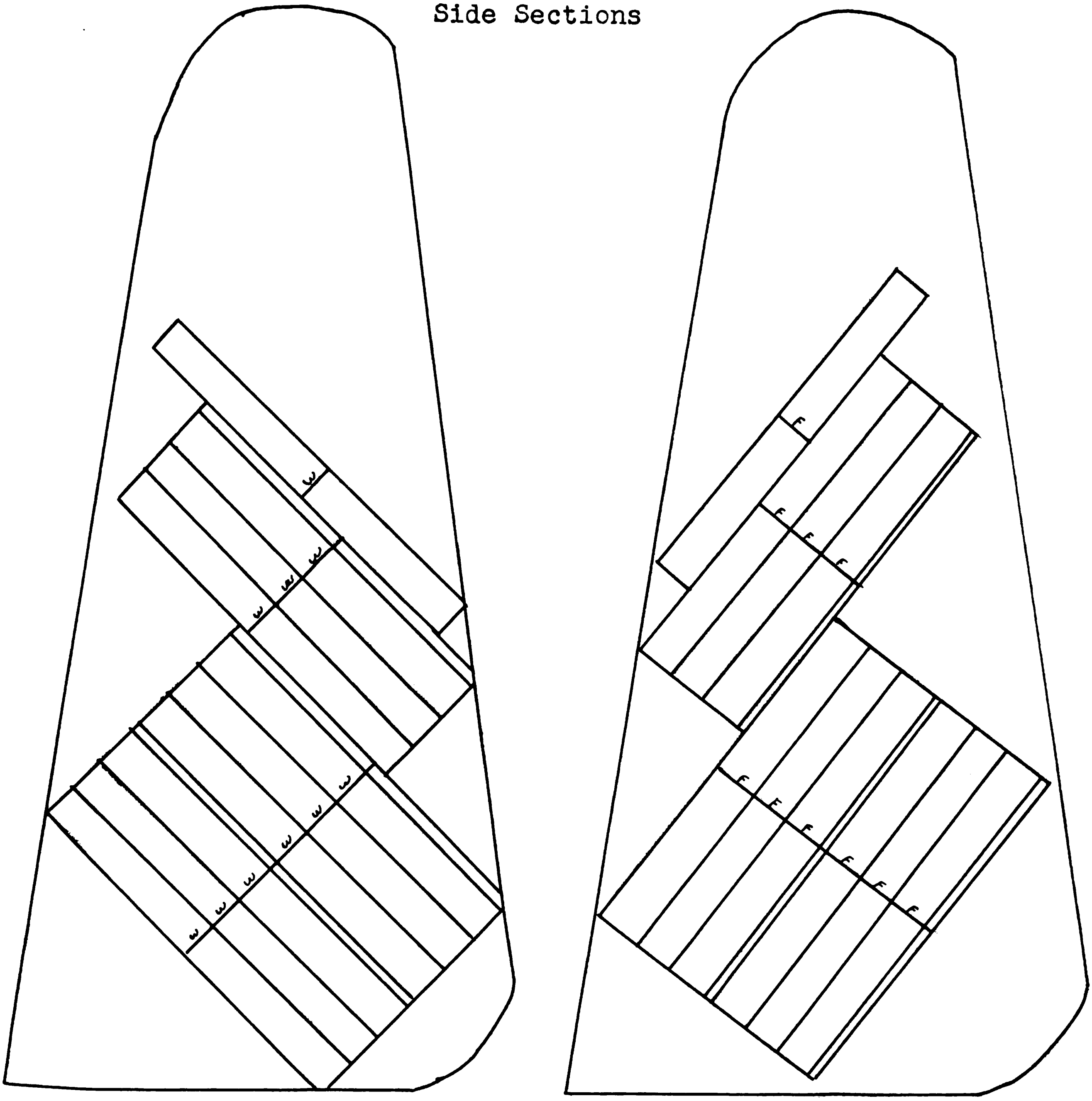
Satin



A - abrasion
wt. - weight
Friction

PLATE IV

Cutting Chart
Satin
Side Sections

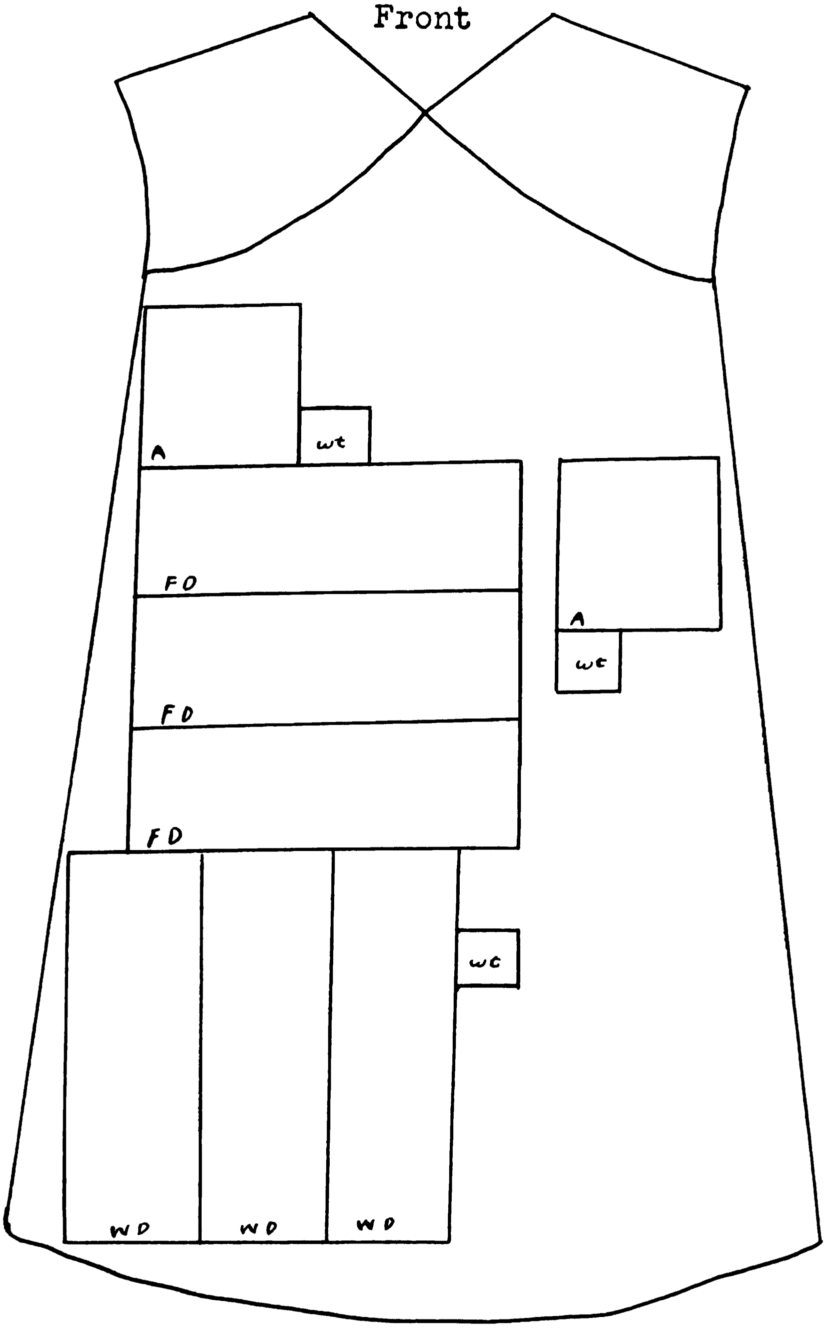


w - warp breaking strength
f - filling breaking strength

PLATE V

Cutting Chart

Tricot
Front

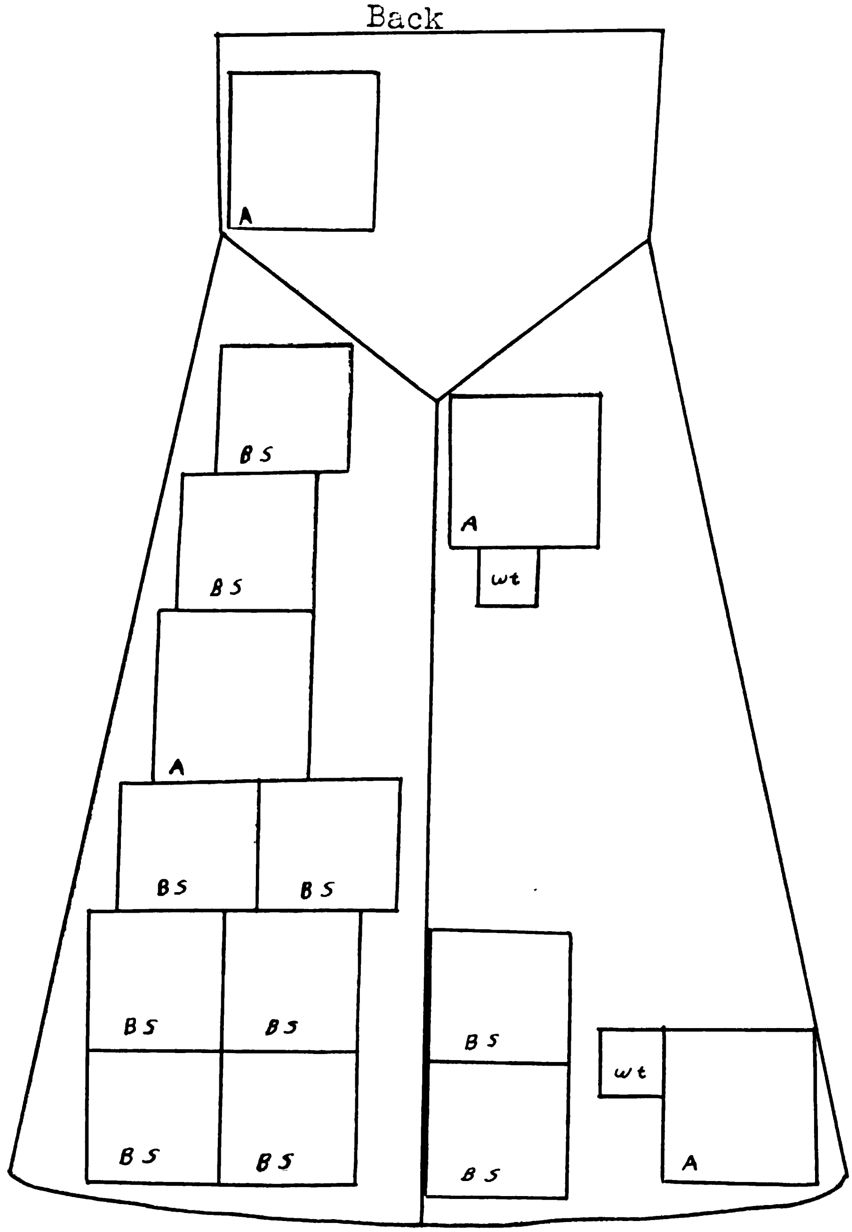


A - abrasion
Wt. - weight
FD - filling drapability
WD - warp drapability

PLATE VI

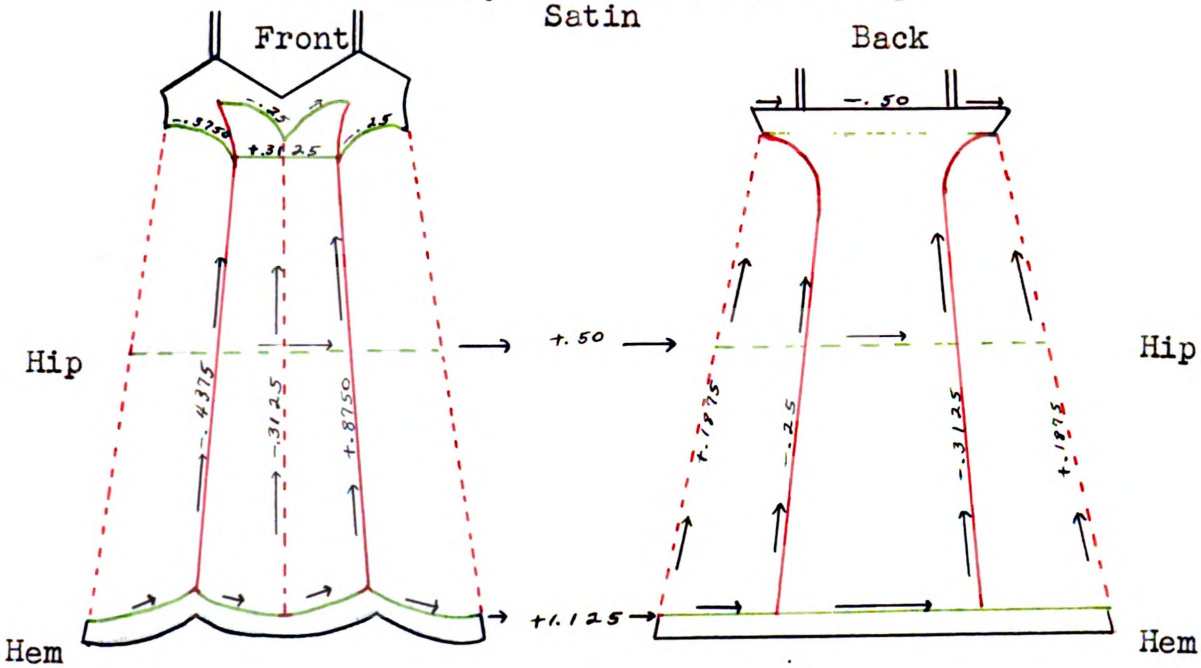
Cutting Chart

Tricot

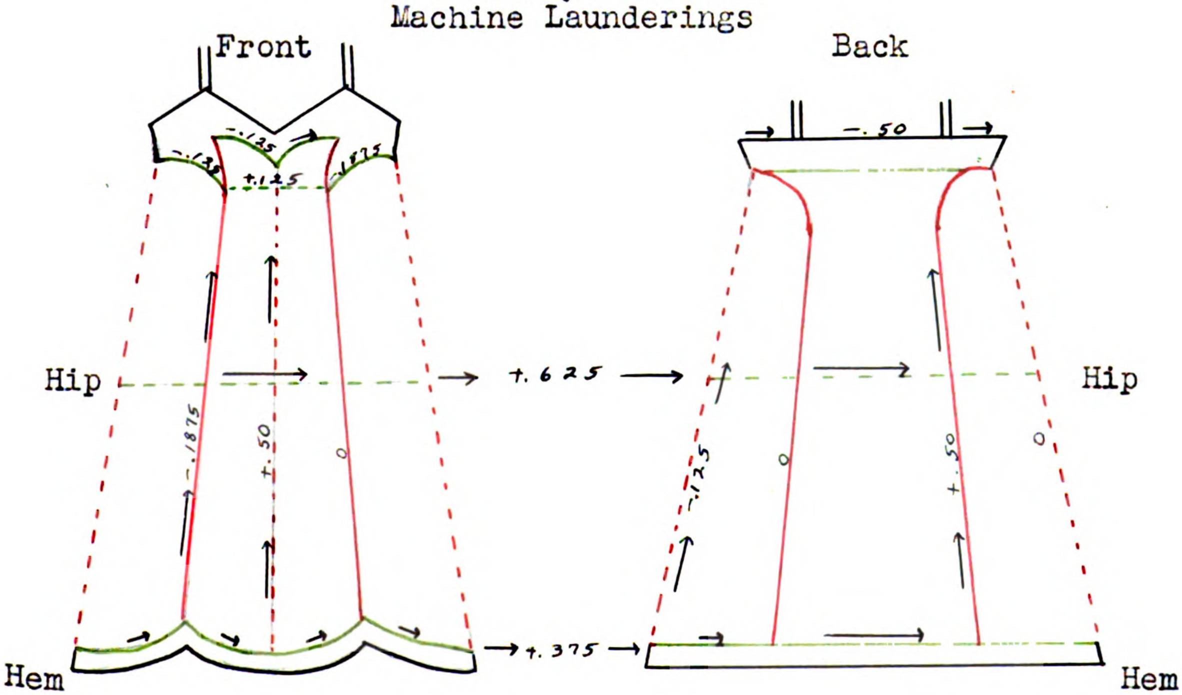


A - abrasion
BS - bursting strength
Wt - weight

Shrinkage in Inches
After Thirty Five Hand Launderings
Satin



Thirty Five
Machine Launderings

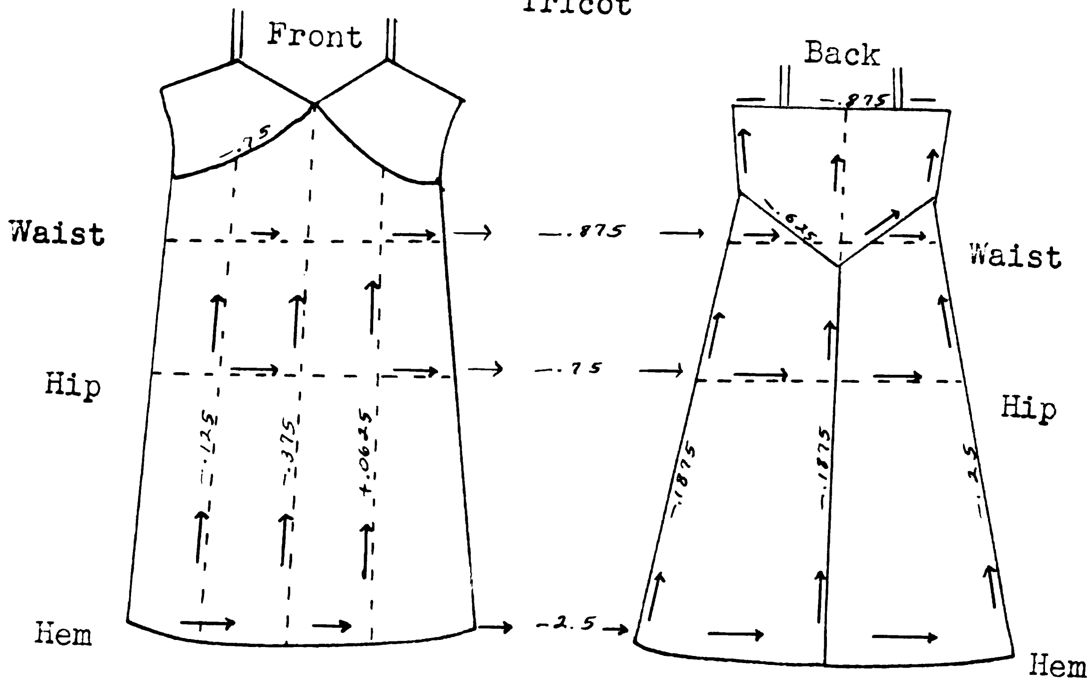


Indicates location of linear measurements

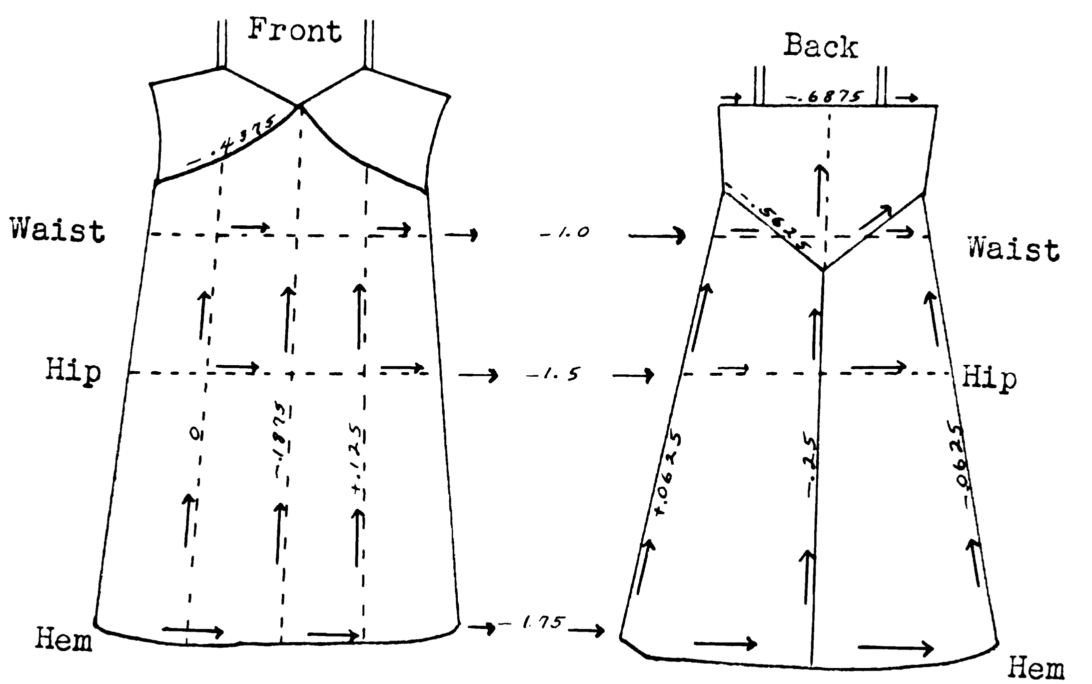
Indicates location of width measurements

PLATE VIII

Shrinkage in Inches
After Thirty Five Hand Launderings
Tricot



Thirty Five
Machine Launderings



- - - - Indicates location of linear measurements

Indicates location of width measurements

PLATE IX

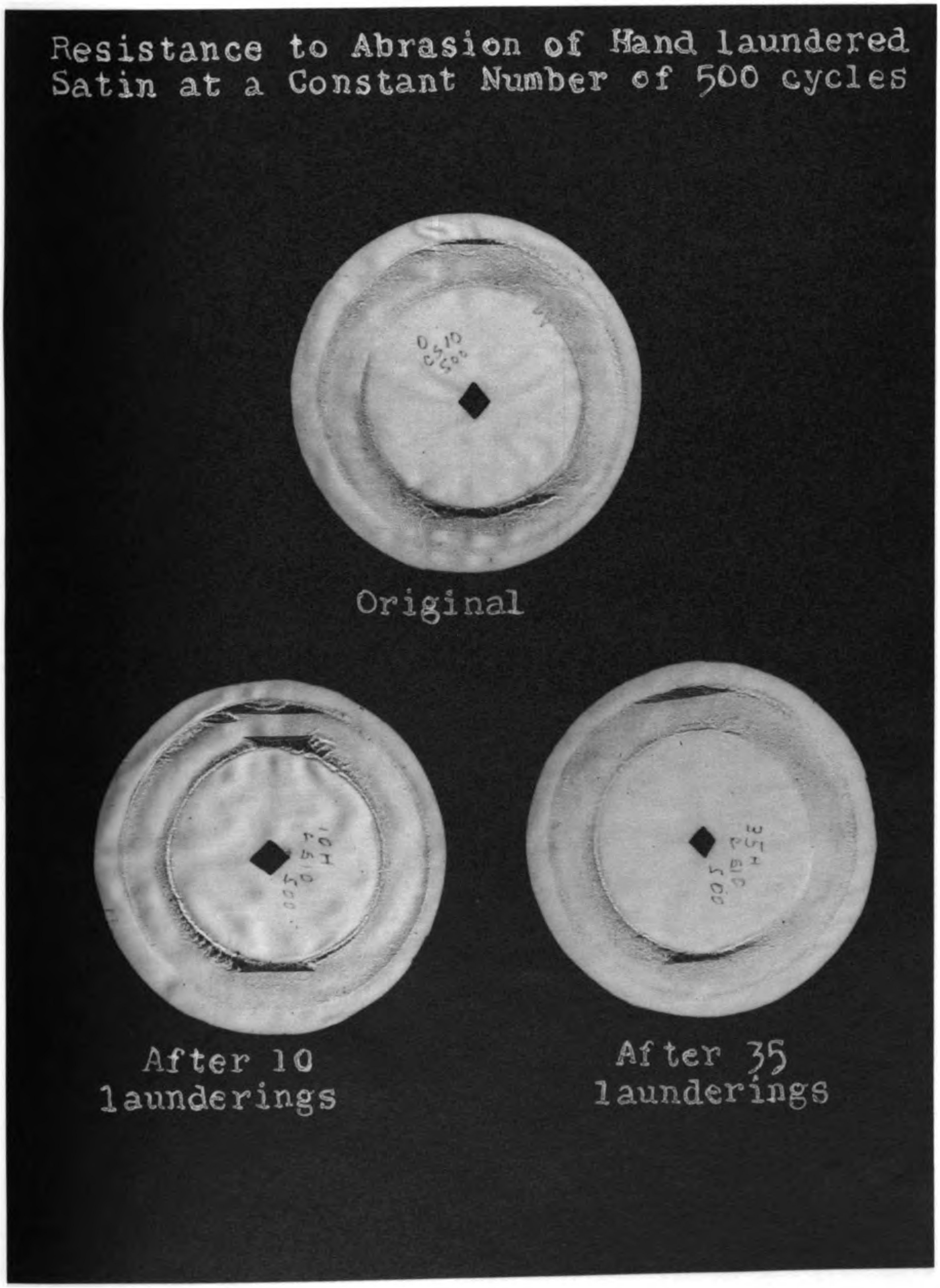
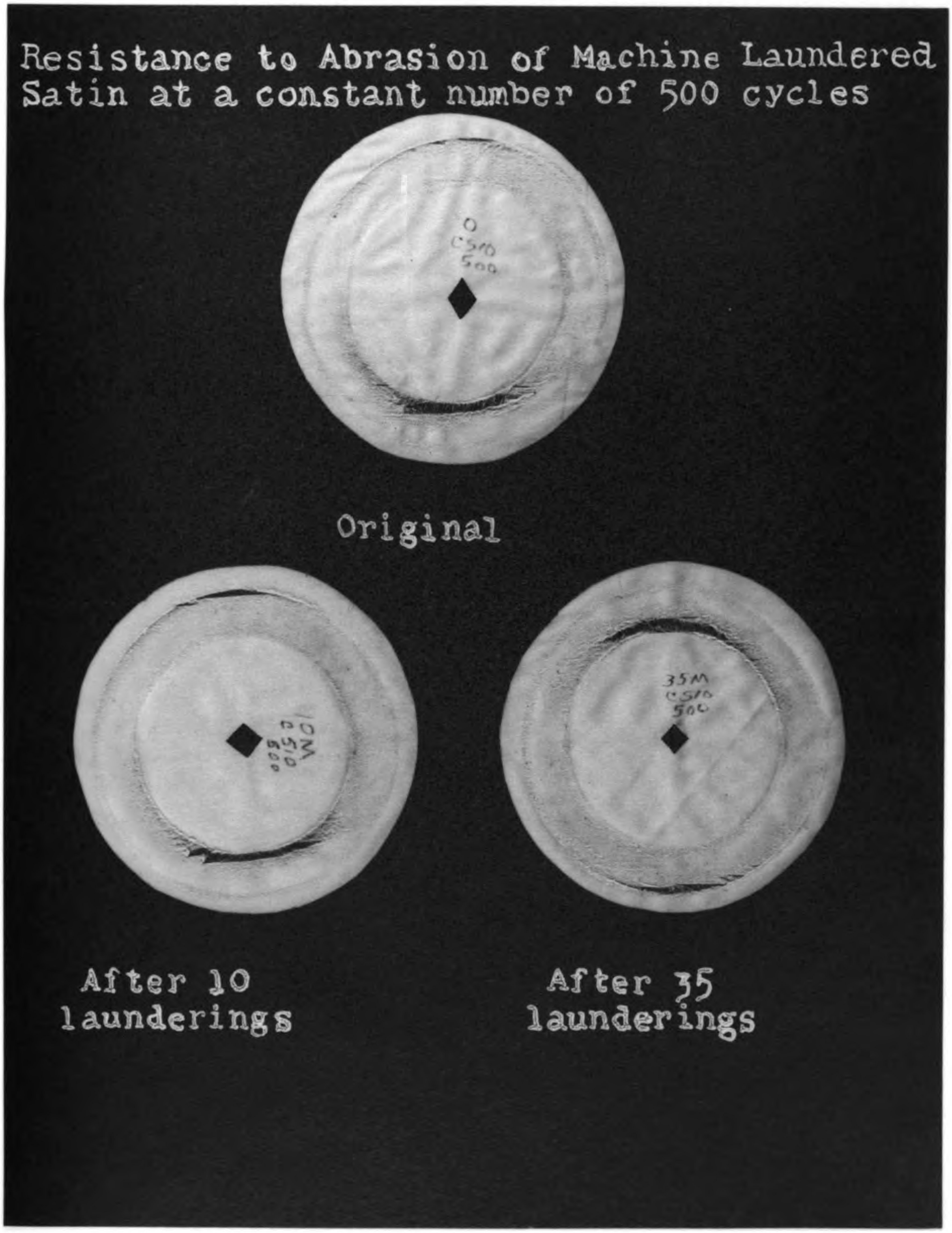

Resistance to Abrasion of Hand laundered
Satin at a Constant Number of 500 cycles
Original
After 10
launderings
After 35
launderings

PLATE X


Resistance to Abrasion of Machine Laundered Satin at a constant number of 500 cycles
Original
After 10 launderings
After 35 launderings

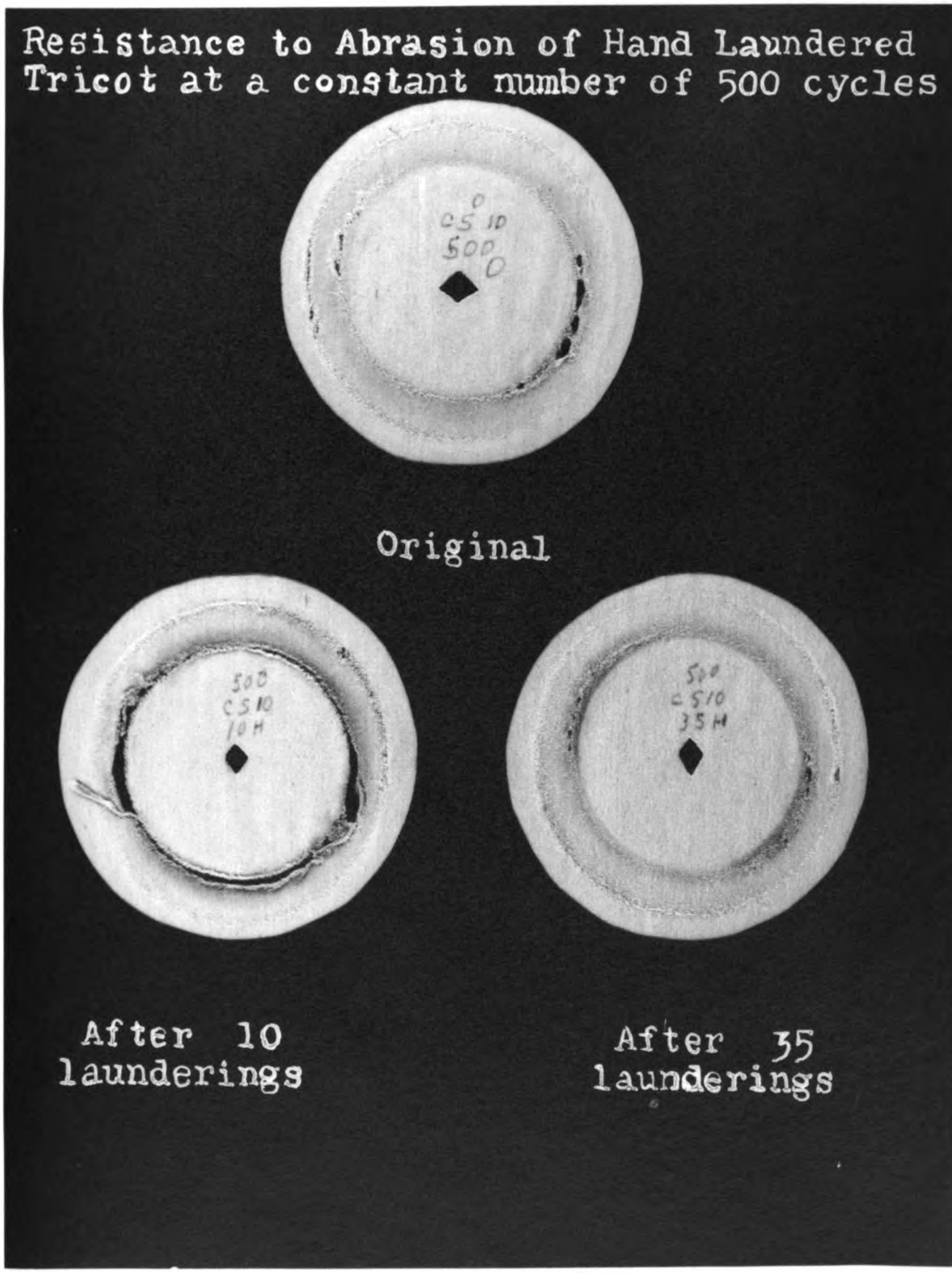
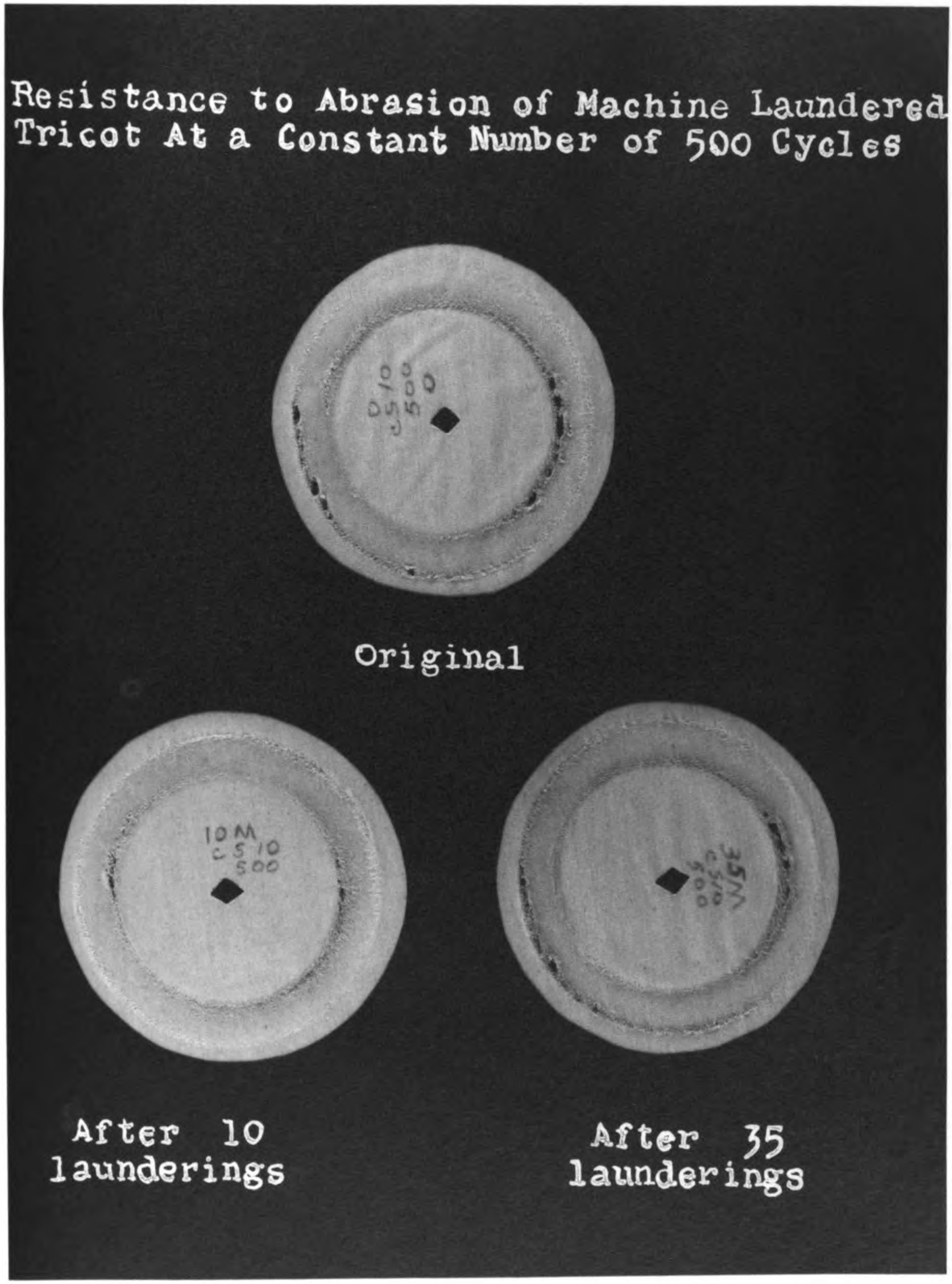

Resistance to Abrasion of Hand Laundered
Tricot at a constant number of 500 cycles
Original
After 10
launderings
After 35
launderings

PLATE XII



Resistance to Abrasion of Machine Laundered Tricot At a Constant Number of 500 Cycles

Original

After 10 launderings

After 35 launderings

CHART I

Performance In Laundry

Fabric	Method of Laundry	No. of L	Course Count: No. per inch: Wales	Course Count: No. per inch: Courses	Course Count: % Change: Wales	Course Count: % Change: Courses	Yarn Count: No. per In.: W	Yarn Count: No. per In.: F	Yarn Count: % Change: W	Yarn Count: % Change: F	Weight: oz. per sq.yd.	Weight: % Ch.	Thickness: Inches	Thickness: % Ch.
Tricot	Hand	0	54.6	30.5							2.352		.0103	
		5									2.5033	+6.433		
		10	55.6	31.7	+1.83	+3.93					2.5111	+6.764	.0110	+6.80
		20									2.5179	+7.053		
		35	55.56	31.5	+3.30	+3.28					2.5867	+9.979	.0110	+6.80
	Machine													
		5									2.4752	+5.238		
		10	57.5	32.0	+5.31	+4.92					2.5186	+7.083	.0105	+1.94
		20									2.5054	+6.522		
		35	57.8	32.0	+5.86	+4.92					2.5641	+9.018	.0105	+1.94
Satin	Hand	0					293.0	129.4			2.4999		.0061	
		5									2.4729	-1.08		
		10					292.5	130.0	- .17	+ .46	2.4750	- .96	.007	+14.75
		20									2.4821	- .712		
		35					298.4	131.6	+1.84	+1.70	2.4699	-1.20	.007	+14.75
	Machine													
		5									2.4939	- .240		
		10					289.2	130.0	-1.30	+.46	2.4832	- .668	.0071	+16.39
		20									2.5252	+1.012		
		35					296.8	129.6	+1.30	+.15	2.5535	+2.144	.0068	+11.47

CHART I (Continued)

Performance in Laundry

Fabric	Method of Laundry		Dry Warp % Ch.	Dry Warp Lbs.	Dry Filling % Ch.	Dry Filling Lbs.	Wet Warp % Ch.	Wet Warp Lbs.	Wet Filling % Ch.	Wet Filling Lbs.
					Breaking Strength					
Satin	Hand	0		71.8		30.9		55.6		23.8
		10	+36.35	97.9	+ 5.66	32.65	+50.0	83.4	+33.61	31.8
		35	+44.71	103.9	+32.04	40.8	+41.19	78.5	+40.76	33.5
	Machine	0		71.8		30.90		55.6		23.8
		10	+21.87	87.5	+41.26	43.65	+46.40	81.4	+64.07	39.05
		35	+51.39	108.7	+15.53	35.70	+52.15	84.6	+ 5.46	25.1
					Elongation					
Satin	Hand	0		23.48		21.8		20.73		18.59
		10	+ 38.97	32.63	+ 8.67	23.69	+ 51.52	31.41	+27.43	23.69
	Machine	0		23.48		21.8		20.73		18.59
		10	-12.27	20.6	+39.54	30.42	- 4.39	19.82	+61.21	29.97
		35								

CHART I (Continued)

Performance in Laundry

			Abrasion*				Drapability**		Color***
			First Sign of Wear		Hole				
Fabric	Method of Laundry	No. of L	% Ch.	Cycles	% Ch.	Cycles	% Ch.	Geo. Mean	% Whiteness on Color Wheel
Tricot	Hand	0		150.0		286.0		0	86
		10	+15.8	173.7	+50.46	430.3		0	82
		35	- 5.33	142.0	- 5.35	270.7		0	82
	Machine								
		0		150.0		286.0		0	86
		10	+ 9.55	164.33	+16.08	332.0		0	83
		35	+ 2.67	154.0	+13.39	324.0		0	84
Satin	Hand	0		240.0		610.00		21.35	95
		10	- 1.79	235.7	+28.69	785.00	+5.90	22.61	88
		35	-15.42	203.0	- 5.79	574.0	+4.36	22.28	87
	Machine								
		0		240.0		610.00		21.35	95
		10	-27.21	174.7	-13.77	526.00	+11.38	23.78	88
		35	-30.29	167.3	-10.61	545.3	+52.27	32.51	88

*Ave. of 3 determinations
**Ave. of 3 determinations
***Ave. of 5 determinations

CHART I (Continued)

Performance In Laundry

Fabric	Method of Laundry	No. of L	Bursting Strength Dry % Ch.	Bursting Strength Dry Lbs.	Bursting Strength Wet % Ch.	Bursting Strength Wet Lbs.
Tricot	Hand	0		103.4		88.4
		10	- 8.70	94.4	+ 3.62	91.6
		35	-26.89	75.6	-24.89	66.4
	Machine					
		0		103.4		88.4
		10	- 8.12	95.0	- 1.36	87.2
		35	-21.28	81.4	-13.12	76.8

CHART II

Average Per Cent Dimensional
Change In Slips After Laundry

No. of L		Vertical Satin	Vertical Tricot	Horizontal Satin	Horizontal Tricot
0					
	Hand				
	Machine				
1					
	Hand	+ .23	+ .18	-1.52	- 1.04
	Machine	- .32	+ .32	- .07	- 2.34
2					
	Hand	- .47	- .15	-1.73	- 1.78
	Machine	- .87	- .13	-1.34	- 2.59
3					
	Hand	- .54	- .10	-1.36	- 1.76
	Machine	- .57	+ .06	-1.17	- 2.10
4					
	Hand	- .31	- .07	-1.37	- 1.87
	Machine	- .44	- .44	-1.14	- 2.25
5					
	Hand	- .43	- .37	-1.24	- 2.32
	Machine	- .50	- .48	-1.26	- 2.79
10					
	Hand	- .48	- .39	-1.56	- 3.13
	Machine	- .46	- .39	- .84	- 2.93
20					
	Hand	- .02	- .27	- .85	- 2.59
	Machine	+ .08	+ .01	-1.10	- 2.80
35					
	Hand	- .02	- .51	- .98	- 3.47
	Machine	+ .31	+ .11	- .93	- 2.89

CHART III

Vertical Dimensional Change of Satin*

No. of L		Right Side Seam % Ch.	Left Side Seam % Ch.	Right Side Front % Ch.	Left Side Front % Ch.	Center Front % Ch.	Right Side Back % Ch.	Left Side Back % Ch.
(1) 1	Hand	+.66	+ .48	+1.32	- .75	+ .25	- .18	- .19
	Machine	0	- .58	- .19	- .87	- .10	+ .09	- .57
(1) 2	Hand	+ .48	- .20	+ .57	-1.50	-1.24	- .19	-1.24
	Machine	-1.23	-1.13	- .66	-1.65	- .87	+ .18	- .76
(1) 3	Hand	+ .48	0	0	-2.27	- .48	- .66	- .86
	Machine	- .28	- .09	- .48	-1.23	- .68	- .67	- .57
(1) 4	Hand	+ .29	- .20	+ .47	-1.22	- .27	- .37	- .86
	Machine	+ .28	- .66	- .10	-1.52	- .39	- .10	- .57
(1) 5	Hand	- .09	- .29	+ .47	-1.22	- .37	- .66	- .86
	Machine	- .09	- .74	- .38	-1.60	- .19	- .01	- .48
(1) 10	Hand	- .28	- .10	+ .38	-1.31	- .37	- .85	- .86
	Machine	- .38	- .38	- .57	-1.33	- .29	+ .18	- .48
(2) 20	Hand	+ .95	+ .76	+2.65	-1.48	- .76	-1.31	- .95
	Machine	+ .19	- .37	0	- .37	+1.15	+1.13	0
(2) 35	Hand	+ .57	+ .57	+ 2.65	-1.30	- .94	- .93	- .76
	Machine	0	- .34	0	- .55	+1.54	+1.51	0

*Measured to the nearest 1/16 inch

(1) Average of two determinations
(2) One determination

CHART IV

Horizontal Dimensional Change of Satin*

No. of L		Curved Bust Front % Ch.	Bust Front % Ch.	Right Bust Under-arm % Ch.	Left Bust Under-arm % Ch.	Bust Back % Ch.	Hip % Ch.	Hem % Ch.
(1) 1	Hand	-3.36	+1.86	-3.45	-3.17	-4.58	+1.06	+1.00
	Machine	- .25	- .53	- .96	-1.80	-3.30	+5.22	+1.12
(1) 2	Hand	-3.87	+4.59	-3.48	-3.93	-2.21	- .18	+ .87
	Machine	-1.30	- .07	-3.48	-3.53	-3.57	+1.90	+ .67
(1) 3	Hand	-2.58	+ .91	-3.57	-3.60	-3.24	+ .47	+2.07
	Machine	- .51	- .48	-3.06	-3.53	-4.08	+3.05	+ .42
(1) 4	Hand	-2.58	- .02	-3.07	-3.17	-3.02	+ .60	+1.64
	Machine	+ .54	- .55	-3.52	-3.56	-4.29	+2.89	+ .53
(1) 5	Hand	-2.32	+ .91	-4.34	-2.69	-3.26	+1.07	+1.98
	Machine	+ .54	-1.44	-3.51	-3.56	-4.29	+2.89	+ .53
(1) 10	Hand	-2.32	- .01	-3.93	-4.03	-3.74	+1.22	+1.88
	Machine	+ .57	0	-2.64	-2.68	-4.29	+2.60	+ .53
(2) 20	Hand	-3.06	+3.70	-2.50	-3.45	-2.88	+ .89	+1.33
	Machine	- .51	0	-2.52	-1.69	-3.85	+ .23	+ .65
(2) 35	Hand	-2.04	+4.63	-3.33	-5.17	-3.85	+1.19	+1.70
	Machine	-1.01	+1.78	-2.52	-1.69	-3.85	+ .23	+ .56

*Measured to the nearest 1/16 inch

(1) Average of two determinations
(2) One determination

CHART V

Vertical Dimensional Change of Tricot*

No. of L		Right Side Seam % Ch.	Left Side Seam % Ch.	Right Side Front % Ch.	Left Side Front % Ch.	Center Front % Ch.	Center Back % Ch.
(1) 1	Hand	0	+ .09	+ .40	+.40	+.18	+ .001
	Machine	+ .09	+ .45	+.69	+.59	+.36	- .26
(1) 2	Hand	0	.00	- .102	- .20	- .26	- .36
	Machine	- .27	+ .0005	+ .10	+.30	- .09	- .80
(1) 3	Hand	- .44	+ .004	+.30	- .30	- .35	+ .18
	Machine	- .36	+ .18	+.60	+ .10	+ .36	- .53
(1) 4	Hand	- .004	- .09	0	+ .10	- .18	- .27
	Machine	- .71	- .36	- .10	- .30	- .18	- .97
(1) 5	Hand	- .70	- .44	- .30	+ .10	- .26	- .62
	Machine	- .76	- .36	- .10	- .49	- .18	- .97
(1) 10	Hand	- .35	- .60	+ .10	- .50	- .26	- .71
	Machine	- .53	- .36	- .20	- .10	- .36	- .80
(2) 20	Hand	0	- .34	+.20	- .40	- .88	- .18
	Machine	0	+ .36	+ .19	+ .39	- .35	- .53
(2) 35	Hand	- .7	- .52	+.2	- .4	-1.1	- .54
	Machine	- .18	+.18	+.39	0	- .36	- .71

*Measured to the nearest 1/16 inch

(1) Average of two determinations
(2) One determination

CHART VI

Horizontal Dimensional Change of Tricot*

No. of L		Bust Front % Ch.	Top of Slip Back % Ch.	Normal Waist Line % Ch.	Curved Waist Back % Ch.	Hip Line % Ch.	Hem % Ch.
(1) 1	Hand	- .65	-1.96	- .37	-1.71	+ .15	-1.69
	Machine	-2.75	-2.82	- .76	-3.99	-1.50	-2.20
(1) 2	Hand	-1.28	-4.07	- .87	-1.69	0	-2.80
	Machine	-2.40	-3.61	-1.13	-3.58	-2.41	-2.43
(1) 3	Hand	- .63	-3.10	-1.40	-2.13	-1.27	-3.01
	Machine	-1.90	-1.03	-1.70	-2.58	-2.87	-2.55
(1) 4	Hand	- .96	-2.91	-1.09	-2.64	- .47	-3.14
	Machine	-1.38	-3.01	-1.70	-1.99	-2.71	-2.71
(1) 5	Hand	-1.46	-3.88	-1.94	-2.00	-1.30	-3.37
	Machine	-2.24	-3.41	-1.70	-2.58	-3.59	-3.25
(1) 10	Hand	-3.05	-4.66	-2.27	-3.18	-1.73	-3.87
	Machine	-2.75	-3.81	-1.70	-2.58	-3.47	-3.25
(2) 20	Hand	-3.07	-4.58	- .33	-2.85	- .81	-3.88
	Machine	-2.08	-3.66	-1.54	-3.54	-3.19	+2.78
(2) 35	Hand	-3.68	-5.34	-2.3	-3.56	-1.63	-4.31
	Machine	-2.42	-4.47	0	-3.54	-3.67	-3.24

*Measured to the nearest 1/16 inch

(1) Average of two determinations
(2) One determination