A STUDY OF THE PERFORMANCE OF A GROUP OF CRUSH-RESISTANT TREATED RAYON SUITINGS IN LAUNDERING AND DRY CLEANING

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By

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INTRODUCTION

For many years the textile industry has continuously searched for new fibers and finishes in order to make their fabrics more acceptable to the consumer buyer. The result of these efforts is the ever increasing variety of materials from which to choose when selecting yard goods and ready to wear.

Decline in purchasing power plus higher cost of woolens and worsteds due to the "wild wool prices" (59) have stimulated the consumer to find less expensive materials comparable in serviceability and appearance. Earlier uses of rayon and acetate were in competition chiefly with cotton and silk. Now with their additional refinements they are put on the market simulating and therefore competing with wool. (59) Yarns can be manufactured of acetate and viscose and woven into fabrics simulating woolen and worsted fabrics in appearance and hand. Resins are applied to these materials which converters claim will improve their shrinkage, crush resistance and recovery from wrinkling.

Today the consumers' prime interest seems to be the wrinkle recovery of the fabric in the apparel they purchase. The typical question asked ten years ago was, "Will it shrink?" Today the salesperson more often hears, "Will it wrinkle?" or "Will the wrinkles hang out when it's hung in the closet?" Advertisers in many consumer periodicals stress this functional treatment under their own trade name with "wrinkle resistant", "wrinkle shed", "crush resistant" or a similar term included in the advertising copy.

Recently research studies have indicated that not finish alone but the inherent physical characteristics of the fiber and the fabric construction play a major role in wrinkle recovery.

Rayon suitings, simulating woolen and worsted suitings have been seen in abundance on the retail market during the past two years. A large percentage of these fabrics have been treated with finishes which manufacturers, converters and retailers claim will resist wrinkling. Will they really resist wrinkling? Will they retain their crush resistance after they are laundered or dry cleaned? Will they retain their original physical appearance? Do they wear as well as wool? These are the questions asked by many consumers. Comparatively little consumer research has been done on the effectiveness and permanence of these finishes in successive dry cleanings or launderings, so to partially answer the above questions is inherent in the purpose of this study.

The general objective then is an evaluation and comparison of the initial wrinkle recovery, drapability and serviceability characteristics of eight selected all-rayon suiting fabrics which have been given a crush-resistant treatment. These fabrics closely resemble traditional woolen and worsted suitings and are currently used in both men's and women's apparel.

Specific objectives are: (a) to compare the initial physical characteristics of these two groups of suitings which vary in weave and yarn structure, thickness, weight per square yard, yarn count, and percentage amounts of blended viscose rayon and acetate; (b) to compare the initial physical characteristics of the "treated" gabardine with the greige or "untreated" cloth in characteristics of wrinkle recovery, drapability, compressibility, compressional resilience, tensile strength, weight and abrasion resistance; (c) to check the validity of the manufacturer's, distributor's or retailer's claims for initial crush-resistance and wrinkle recovery; and (d) to determine if initial price bears a relationship to the performance in these two groups of "treated" fabrics.

A second major objective is (a) to determine the relative durability and/or performance in use of the crease resistant finishes applied to these two types of suitings following a specified number of launderings and dry cleanings by comparing their initial performance characteristics with those same characteristics after twenty dry cleanings and launderings; (b) to show to what extent durability or performance is influenced by weave structure and/or yarn structure and the extent and rate of change occurring at specified laundering and dry cleaning intervals; and (c) to compare the effectiveness of the applied finish in repetitive launderings with that in successive dry cleanings.

The third objective is to determine if launderings and/or dry cleanings results in progressive change in their physical and performance characteristics in wrinkle recovery, drapability, compressibility, compressional resilience, dimensional change, tensile strength, resistance to abrasion and colorfastness.

REVIEW OF LITERATURE

The first half of the twentieth century has seen a tremendous expansion in the use of rayon and spun rayons, which has been largely based on the steady improvement in their quality. It was long recognized that a needed improvement in these fabrics was their launderability. The consumer wanted rayon fabrics which could be laundered without excessive shrinkage or stretchage, slippage, or loss of color.

Fabrics and garments were sought which would hold their shape, color and body during their life. The use of faster dyes helped solve the color problem, and while this increased costs, it likewise widened markets. The adoption of better construction reduced slippage and the use of resins helped still more in effecting increased dimensional stability and crease resistance. (46)

The most widely used method was developed in 1918 by chemists of Tootal, Broadhurst, Lee Company, Ltd., of Manchester, England. For fourteen years they continuously sought means of giving cottons and rayons comparable resilience inherent in animal fibers such as wool. (10)

The process derived from these many years of research included the formula for the resin, methods of application and padding, drying, and curing temperatures as well as length of curing, washing and final drying procedures.

For the preparation of the resin it was necessary to know that formaldehyde was applied to the fabric from a water solution of the monomer or precondensate in the presence of a catalyst which would split off acid at a high temperature used for curing. The following formula was of sufficient strength to give fabrics crease resistance and low residual skrinkage if properly applied: (30 pounds of urea formaldehyde (dry), 1.2 pounds of diammonium phosphate (catalyst), 0.25 pound of wetting agent and water to make 12 gallons). (11) To apply the resin, the fabric was impregnated with the solution on a 2-roll or 3-roll padder with two or more dips to insure complete and uniform impregnation. (50) The drying operation was an important phase. The fabric was placed in a dryer having a temperature of approximately 180° F., with 200° F. as maximum. (11)

The resin treated fabric was then cured to achieve polymerization of the resin monomer to the insoluble form. Curing for five minutes at 300° F. was a good all round procedure to follow, but the best condition of time and temperature for curing had to be determined by each mill for each fabric as the type, weight and construction of the fabric had to be taken into consideration. (28) Too low a temperature or too short a curing time would not allow complete polymerization of the resin while too high a temperature or curing too long a period of time would increase the chances for damage to the rayon and result in a loss in tensile strength and abrasion resistance. If insufficient curing occurred, the finished fabric tended to develop an extremely unpleasant "fishy" odor. (11)

The cured fabric was then washed in a beck containing soap for 15 to 20 minutes at a temperature of 120° to 160° F. to remove excess chemicals and surface resin. The final drying, which consisted of extracting by centrifuging and opening by hand was carefully carried out. The goods were then given any final dry finishing operations which may have been required. (37)

This process was applied to cottons and rayons for several years by this British firm in Manchester. (37) It was not until 1928 that urea-formaldehyde resin was made and used commercially in the United States. (32) However, the Tootal, Broadhurst, Lee Company, Ltd., applied for and received a U.S. Patent, (No. 1,734,516), in 1929 which had an expiration date of November 1946. The issuing of this patent benefited the T. B. Lee Company, Inc., an American subsidiary established by the parent British firm. This patent, which employed the use of the urea-formaldehyde resin, covered specifically production of crease or crush resistant finishes in cellulosic and other materials. Claim 7, was of extreme importance to this British firm during the life of this patent as it protected them against unauthorized use of this method and the use of their trade mark. It reads as follows: "The process of rendering a textile material substantially less liable to creasing or crumpling without substantially lessening its suppleness, which comprises impregnating the individual fibers with a liquid comprising a solidifiable agent, removing the impregnating agent, if any, from between the fibers, and solidifying the agent." (37) Fabrics given this treatment were said to be "Tebilized". (9)

This "Tebilized" process which was developed originally for cottons, would never have assumed much importance for such applications. Actually, it was the market for spun rayon dress goods and various types of sportswear which caused the rapid and phenomenal growth in the use of this Tebilized process. (37) Other concerns quickly adopted similar processes and millions of yards of rayons, especially spun rayons, were sold under such trade names as Vitalized, Unidure, Bradura, indicating muss or crease resistance resulting from impregnating the fabric with resin. (45) In addition to crease proofing, these processes also produced shrinkage control, improvement in "hand" and drape and increased wet tensile strength. One disadvantage, however, was that wear or abrasion resistance of the fabric was normally decreased. (37)

As the years passed the urea-formaldehyde low polymer products became increasingly plentiful. In 1939 (32) another thermosetting resin, melamine formaldehyde, became available, and enabled the field of resin application for textiles to broaden considerably. (37) It was very difficult to take melamine, which is a triaminotriazine and combine it with formaldehyde to yield a product that would be satisfactory to the textile trade for applications to all types of fibers, including rayons, wool, cotton, linen, aralac and nylon. However, after several years of intensive research work at

the Stamford Laboratories of the American Cyanamid Company, an alkylated methylol melamine was produced which had qualities that had seemed impossible to develop during the previous years. (37) They called their process "Lanaset". Later the Monsanto Chemical Company started manufacturing a melamine derivative which they marketed under the trade name "Resloom". (49)

In sharp contrast to the corresponding urea-formaldehyde types, this melamine product "Resloom" was miscible with cold water in all proportions; had excellent stability to storage; (37) formed baths more stable to accelerator; had less tendency to form odors; was much more resistant to chemical degradation and to boiling water; and minimized the gas fading of acetate colors. (28) In order to obtain equivalent results in any given fabric construction, only one-half the amount of a melamine resin was necessary; a melamine formaldehyde resin content of 5% solids in a fabric being equivalent to roughly 10% solids of a corresponding urea-formaldehyde product. (37)

A difference between the two types of resins, which was extremely important, was the manner of chlorine absorption from laundry bleach liquors. The urea-formaldehyde resins absorbed chlorine and caused subsequent tendering in either cotton or spun rayon fabrics during ironing, unless such fabrics had been given a thorough anti-chloring. Although the corresponding melamine types likewise absorb chlorine, they do so in an entirely different manner, with little or no subsequent loss in tensile strength, even without antichloring. Chlorine absorption tests carried out by several independent laboratories, showed a spun rayon fabric finished with a urea-formaldehyde resin content of 8% to have warp tensile strength losses varying from 22 to 60 pounds and 12 to 27 pounds in the filling. The corresponding melamine finished fabric showed a 6% loss which was practically the same strength loss as the cloth before finishing. The important factor in connection with this investigation is the fact that the urea-formaldehyde treated cloth showed wide variation in tensile strength loss, whereas the corresponding melamine-formaldehyde finished sample did not.(37)

The effect of chlorine bleaching on cloth treated with urea or melamine resins practically demands that garments made from such cloth should never be chlorine bleached or be given an extremely efficient antichlor. Since all present crease resistant finishes contain either urea or melamine resins, all garments made from them should be distinctively labeled as a warning for laundries to antichlor. The need for such labels is outstanding. It is often impossible to tell fine corded cotton from rayon and many laundries claim they chlorine bleach all white goods. Unless a label specifically warning against chlorine bleaching is attached, white crease resistant rayon garments probably will be, or are being, bleached. (28)

In spite of the many superior characteristics of melamine formaldehyde, it was not readily accepted for commercial quantity use due to its high cost. In fact, in 1940 Warwick noted that melamine was even then still a costly and almost an unobtainable commodity except in university laboratories. However, in that same year the American Cyanamid Company produced and sold over half a million pounds of melamine. (30)

By 1944 a great amount of study had been given to crease resists and their effects on fabrics dyed with various types of dyestuffs. Results indicated that direct dyes, which were considered the most important for crease resist processing, were usually affected in shade by the urea-formaldehyde product. Browns varied from a red to a dull tone, while tertiary shades were found to be unstable if any one component of the dye would not withstand subsequent processing. Problems were most acute when trying to obtain pale shades, while in the case of heavier shades, particularly blacks; these difficulties did not arise to any appreciable extent. Direct dyes were also affected by fastness to light when treated with the crease-resisting process----some were slightly improved, others were practically unaffected, while still others were reduced in their light fastness. In fastness to washing, all direct dyes were considerably improved by the crease resist process. In fact, this process protected water fastness to an even greater extent than did the two treatments which were normally given to direct dye fabrics to improve their water fastness. With vat dyes, the crease resist process altered the shades very little, but tended to reduce the fabric's fastness to light. Azoic dyed fabrics, when given a crease resist process, changed very little in shade tone but seemed to be improved in their fastness to light. Sulphur colors were not extensively used on fabrics to be given a crease resist treatment, because they were dull and showed appreciable shade changes when the finish was applied. Basic colors were somewhat improved in light fastness when given a crease resisting treatment. (15)

Due to many wartime shortages, both the United States Army and the United States Navy used rayon fabrics treated with formaldehyde resins in official uniforms. The Navy issued a broadcloth blouse for the Waves cut from a rayon fabric impregnated with a 2 to 3% solution of one of the melamine resins. Such resins, if properly applied, had no odor nor did they cause any dermatitis except in extremely rare cases. (26) The United States Army, on the other hand, made the WAC off-duty summer uniform from a crease-resistant rayon fabric that saved time in washing and ironing. (10)

As late as 1944 laboratory tests developed for fabrics given a crease resistant treatment were few. A.S.T.M. 1944 reported that in the field of dress goods and suitings where cotton and rayons were concerned, a considerable amount of emphasis was being placed on crease resistance, resilience, crush resistance, or wrinkle proofing. They did not pretend to know where one began and the other ended. They had heard of countless claims made for the synthetic resins and fibers themselves which were supposed to make a woman's dress crease-proof or make a crease stay in a pair of man's slacks depending on which claim would sell the most goods, but they had no good testing instrument or method for determining these characteristics. (22) On the other hand, during the same year, recovery from creasing and other minimum standards were insured by strict testing by the fabric finishers and by check tests employed by the Better Fabrics Testing Bureau, official testing laboratory of the National Retail Dry Goods Association. Unless a fabric showed 75% recovery from creasing after five minutes under a five pound weight, it could not be labeled as "Tebilized". The crease test the Better Fabrics Testing Bureau reported put more strain on a test piece of fabric than a 200 pound man sitting in a swivel chair put on his suit. (10) It was also noted by another testing laboratory that the identifying colors in stain tests for distinguishing fibers were altered by the urea-formaldehyde finish. (35)

In February of 1945 D. H. Powers, a Director of Sales Development of Textile Chemicals for the Monsanto Chemical Company, announced the results of a study determining the effect of laundering on resin treated rayons. As stated before, the melamine type resins showed that they were tremendously lower in their chlorine absorption than the urea types and that they caused little tendering of the fabrics even where untreated fabrics given the same bleach were damaged. However, a new result was that they seem to exert a protective action rather than a deleterious action on the rayon which was bleached. Also, this melamine type of resin, when properly impregnated into the fiber, gave increasing strength to spun rayon with increasing concentrations. Powers also stated that the amount of rayon which had been impregnated with the urea resin had doubled in the previous year. (44)

In <u>Textile World</u> of March 1945, it was noted that "durable" finishes, with high resistance to creasing, abrasion, dimension change, a drapy or stiff hand, good tensile strength and no chlorine absorption, presented problems both to the finisher and to the user of reworked stock. While it was extremely important from the consumer's point of view that the finish be permanent for the life of the garment, at the same time it was of obvious importance to the textile finisher that he be able to remove this finish in case some error had been made in his operations so that he must either redye or refinish. (29)

In May of 1945 Bouvet, Manager of the Textile Unit of the American Viscose Corporation reaffirmed the fact that for satisfactory results, it was essential that cloth technicians and finishers work as a team. He claimed that cloth must be designed so as to provide sufficient room for the resin. Long and coarse staples were desirable for the sake of resiliency, high spinnability and low twist. He also pointed out that the cloth was to be entirely relaxed, fully shrunk, and most important that it be nearly bone dry before curing. The chief requisites for success were desirable cloth constructions and finishing under low tension. Urea formaldehyde, which did not possess any shrinking properties, was placed on the cloth to anchor the fiber and no satisfactory degree of stability was achieved unless the fabric was fully shrunk at curing time. (5)

During this same month the American Cyanamid Company announced the formation of a new department expressly to handle synthetic resins in the field of textile finishing. This was due to the ever increasing production of synthetic resins for crease proofing and general finishing. (33)

In Rayon Textile Monthly of May 1945, it pointed out that there are two characteristics possessed by urea-formaldehyde resins to which they owe their usefulness in the textile finishing industry. When applied to the fabric in monomeric form as mono or dimethylol urea and polymerized in the fiber a definite improvement in resistance to creasing and to shrinkage during laundering was observed. When the partially polymerized resins were applied to the fabric the molecular size prevented penetration into the fiber and a resin film was therefore formed around the fibers and yarns. Crease resistance was not improved by this treatment but shrinkage was controlled. This latter application also altered the "hand" of the fabric by imparting a certain amount of stiffness and "body". The extent of these added characteristics depended almost entirely on the molecular weight of the polymer employed. High polymers produce more stiffness and "body" than low polymers. (41) A disadvantage, however, was that unless mixed with monomers or low polymers, a trend was evident that the higher the initial degree of polymerization of the impregnant, the lower the wash fastness. (28)

In 1945 it was possible to obtain modified urea-formaldehyde resins in monomeric or polymeric form which were compatible with the quaternary ammonium water repellent compounds and could be applied successfully in conjunction with them. When monomeric urea-formaldehyde compounds were employed with the quaternary ammonium water repellent compounds, excellent crease resistant and water repellent effects were obtained, and resistance to laundering shrinkage was imparted. The lubricating and "bodying" effect of the water repellent compounds apparently overcame the dry, "sandy" feel which was usually apparent in resin treated fabrics and produced a smooth full, softness which was very desirable. The wearability properties of fabrics so treated, as measured by abrasion resistance tests, were also found to be very much higher than was ever obtained with the usual urea-formaldehyde treatment. Therefore, in this single application of resins a fabric was obtained which possessed water repellency, resistance to spotting and shrinking, improved wearability and a desirable "hand". (41)

With the resin-treated fabrics came the necessity of developing production processes that would insure, beyond any doubt, a permanent finish. The stage of production which had the greatest bearing on the lasting quality of the finish was the curing stage. As stated before, if the fabric were "overcured", which is too high a temperature or too long a curing time, the resin treatment was destroyed. On the other hand, if the fabric were "undercured", that is too low a temperature or too short a time in the curing process, the resin treatment was not "set" and did not have a lasting effect. Therefore, the key to proper curing was control. This could be obtained only by an absolutely uniform temperature throughout the entire curing operations plus a proper relative exhaust of air. Two types of machines were recommended for the curing process, the Loop Dryer and the Roller Type Dryer. (47)

During the early months of 1945, samples of rayon fabrics with the urea-formaldehyde or melamine formaldehyde resins migrated to the United States from England. It was noticed that the American finish was not in any degree comparable to that on like fabrics finished in Great Britain. Therefore, two representatives of the American Viscose Corporation visited all the important plants in England which did crease resistant resin application work. They reported that there were small differences in the type of equipment or the manufacturing steps used, but in general, the English and the United States plants were much the same. There was one thing, however, that was very noticeable---and that was that, in not a single plant that operated on rayon fabrics were goods rolled or batched following any single productive operation. The only time goods were rolled on paper tubes, was preparatory to shipping to the customer. Each productive operation was carefully planned to relieve every possible degree of tension from the fabric while handling. This was important and needed to be seriously considered by American processing plants. (57)

At this same time Mr. C. C. Wilcock, Chief Chemist of the Droylsden Plant of Courtaulds, Ltd. in England stated that the whole object of the crease-resist finishing treatment was to obtain formation of the resin in the interior of the fibers so that it was essential that the fabric was in its most receptive condition. The fabric should be essentially dry, relaxed and free from starch, and after saturation with the crease-resist solution, the excess liquor then uniformly removed by the nip of the pad mangle. A further point which he made was that if the condensation of the urea and formaldehyde were taken too far, if the temperature of the solution after addition of the catalyst were too high, or if there were not sufficient pressure on the pad to remove surplus liquor, there was a tendency towards resin formation on the surface of the fibers. Any such excess resin was not only valueless but was definitely detrimental to the handle of the fabric. For the same reason, it was also important to avoid migration of the precondensate from the interior to the surface of the fiber during the drying operation prior to curing. This was achieved by carefully regulated even drying conditions. Too high drying temperatures were also avoided for the same reason. Mr. Wilcock felt that the greatest difference in British and American practice was in the use of the overfeed pin stenter which was invariably used in Britain for drying after resin impregnation and prior to curing. In America, the use of the clip stenter was a general practice. The British practice was to dry with controlled minimum tension, while the American current practice made it impossible to dry with a sufficiently low tension. This was one of the main reasons for the difference in handle of British and American crease-resistant spun rayons. (58)

In December of 1945, A. J. Hall stated that melamine-formaldehyde resin would be used even more than previously because it showed greater fastness to washing than urea-formaldehyde resins. He noted that, although the primary reason for application of synthetic resins to fabrics was to give them a better resistance to creasing, it had been found that the additional weighting simultaneously obtained was valuable. In fact, it was likely that such resin treatments would be used for weighting and bulking rayon materials even if no crease resistance was thereby produced. (23)

In March 1946, Raymond B. Seymour of the Industrial Research Institute at the University of Chattanooga stated that materials given a resin treatment were not effective until polymerized or "cured". The polymerization process, which must be carefully controlled, could be observed by the dyeing of samples withdrawn at intervals during the curing since the presence of polymers impeded the penetration of dyes. (49) Along this same line Dr. C. P. A. Koppelmeier's test for the identification of urea resins in wrinkle-proof fabrics was published in Rayon Textile Monthly in December 1946. The procedure involved heating a resin treated fabric with aniline for it was then possible to determine the qualitative and quantitative urea determination in urea-formaldehyde resins. The method would be most helpful in the application of the Tootal, Broadhurst, Lee process for their "Tebilized" application required a resin content of 8%. (40)

In April of 1946 Walter Sump of the Crown Tested Department of the American Viscose Corporation published in both the American Dyestuff Reporter and Rayon Textile Monthly results of research as to the effect of chlorine retention on rayon fabrics. It was pointed out that resins were not the only chlorine retainers. They had definite proof that if a rayon shirt had been starched, the starch would retain chlorine in the subsequent laundering wherever it had not been completely eliminated. Weak spots developed in shirts and caused holes which puzzled the owner of the shirt as well as the laundry and usually lead to a complaint that there was fault in the fabric. (53) In order to test for chlorine retention, Dr. Epelberg of Cluett Peabody Laboratory demonstrated an instrument built by Alfred Suter which would maintain a constant amount of heat on rayon fabrics for a definite period of time. Test specimens were then broken by the tensile strength machine. This test was designed to determine chlorine retention and its effects on rayon fabrics. (52)

During the second half of 1946, much attention was given to equipment used in drying and curing of resin-treated textile fabrics. (39) An important step in the final drying was the extracting and opening of the fabric. Creegan stated it should be carried out carefully but need not be confined to centrifuging and hand opening. Mechanical opening and suction slot extracting were used whenever the final drying was such as to allow relaxation of the fiber. (11)

Helmus, in January 1947 suggested a new criteria for quantity of resins to be used in finishing. He noted that many fabrics were being given a resin treatment that should not have this finish. There were many people who did not realize that when applying urea-formaldehyde resins to acetate and viscose combinations, the resin had no effect on the acetate part of the combination. When a piece of material was given resin to improve its resilience, the resin content on the viscose should only be enough to give the resilience required, and it should not be necessary to load a fiber with material merely for the sake of obtaining a given resin content. The dyer was requested to give resin treatments for a certain percent of resin retention. Many times it was found that the material involved would almost meet the resilience requirements before the application of the crease-resistant finish. During this time the

English textile industry began building the fabric and applying the resin finish to obtain the best results, regardless of the quantity of resin fixed in the fabric. (24)

This idea of building an ideal fabric for crush-resistance and then applying a resin, if necessary, was attempted in 1947. The results were a springy crush-resistant fabric of a plain balanced weave. The warp was a two-ply yarn; one ply was a low-count cotton yarn, the other a high-count (cotton count) filament rayon. The rayon yarn was "buried" in the low-count cotton ply. The filling was a blend containing about three parts mohair and one part staple rayon.

During the early part of 1947 Powell stated that even with care exercised throughout the application of resins, that the construction of the cloth, denier size, length of staple and twist all exerted an important influence on the finished result. (43)

In June, 1947 Fornelli published a process which minimized fiber damage while still imparting crease-resistance to the fabric. As stated before, the production of anti-crease effects was made possible by resin formation inside of the fiber. The presence of resin inside the fiber altered the mechanical and physical interactions but unfortunately caused fiber damage. Therefore, work was carried out to void the penetration of resin into the fiber. According to Raepsaet, Boston and Perlmutter, in order to preserve fibers from direct contact with resins, the cloth was first given a rubber treatment and afterwards impregnated with urea-formaldehyde. The resulting anti-crease effect and the hand of cloth were excellent. (17)

In November 1947 Rayon Textile Monthly published an article on a unique and practical measuring device which permitted textile mills and textile processors to determine accurately the amount of wrinkle resistance in woven fabrics. It was called the "Monsanto Wrinkle Recovery Tester". In describing this new piece of equipment, Dr. D. H. Powers, director of Monsanto Chemical Company's textile chemical department, stated it was a "necessary adjunct" to Monsanto's recent line of washable "Resloom" finishes which made wool, cotton and rayon fabrics both shrink and wrinkle-resistant. The device, developed by Dr. R. F. Nickerson, research chemist at Monsanto's textile laboratory in Everett, Mass., said this device opened opportunities for new fabric constructions by providing more accurate measurement data on the wrinkling characteristics of woolens, worsteds, cottons and rayons. Previously, construction of a consistently muss-resistant man's suiting had been difficult because of unsatisfactory and inconclusive testing methods. It was necessary to know accurately how badly a fabric would muss before anything could be done about improving it. To be able to measure the improvement was important. This new wrinkle recovery tester was a step in that direction. To determine the wrinkle recovery of a sample one end of the creased fabric was inserted in a jaw which held it securely while the other end hung free and was brought in line with a vertical line on the meter. The degree that the free end "bounced back" which was from 0 to 180 degrees after a few minutes suspension was then measured on the meter to show the actual amounts of recovery. The system was built so adjustment could be made to correct the differential in various fabric weights. Among the end results suggested for the tester were establishment of a set of industry standards by which consumers would clearly know the amount of wrinkle resistance contained in wearing apparel as an aid in merchandising. (34)

During 1947, over a dozen patents were found in "Paul Wengraf's Patent Digest" of the American Dyestuff Reporter pertaining to urea- or melamine formaldehyde resins. Curing agents and additions to resins for improving their stability in storage seemed to monopolize the subjects of the patents in connection with the resins. An outstanding feature noted during this same year was a claim made by the Warwich Chemical Company. They stated their resin, "Formaset SR", which imparted a considerable degree of crush resistance and shrinkage control, reduced the moisture regain of a rayon fabric from the normal 11% to 4%, with a subsequent slight gain in dry tensile strength and a very measurable gain in wet tensile strength. (12)

In 1948, both the Harris Research Laboratories (18) and the Stamford Research Laboratories of the American Cyanamid Company, (13) had found many limitations in the generally accepted TBL test for crease resistance. The former laboratory stated that the TBL test was useful and rapid, but failed to distinguish between stiffness and resilience. They found more information for the evaluation of finishes to be obtained by measuring the flexibility and flexural resilience through a series of degrees of folding. This was done by forming the natural fold of the fabric and measuring the height of this fold through a range of loadings. The original height of the natural fold was one measure of stiffness; the work done in further folding was another; and the ratio of the energy recovered on releasing the fold to the work done in forming it constituted a measure of resiliency. (18)

The Stamford Research Laboratories noticed further limitations of the TBL test for crease resistance other than the failure to distinguish between stiffness and resilience. Among these were variable sensitivity between fabrics of good and poor crease resistance when hung on the wire, curvature of the specimen caused by the weight of the hanging ends, twisting of the specimen due to spinning and weaving and handling of the specimen before measurements were taken. Therefore, to minimize the errors in manipulation an instrument called a "Vise Pressure" was developed which eliminated handling between the creasing and measuring of the specimen. The precision of measurement with this instrument was estimated as plus or minus one degree. Preliminary experiments were undertaken and disadvantages of this test readily became apparent. It was observed that when sufficient pressure had been applied to a sample to flatten the fold completely, additional pressure served only to compress the double layer of cloth having no further effect upon the final crease. Therefore, a method was devised whereby the area of application of the creasing force was reduced to a minimum. It consisted of passing a doubled specimen between rotating metal rollers of small diameter (0.5 inch), thereby confining the force to a small area and producing more nearly constant creasing pressures regardless of fabric structure. As with planefaced loading, as described above, a hard cloth sustained greater pressure than a soft cloth. However, with the rollers, difference in pressure at the crease was less than for flat loading because of the reduced area of contact. Compressibility of the cloth also affected to some extent the duration of the creasing period when rollers were used. The material of slightly compressible cloth was creased for a shorter time than that of a higher compressible cloth. This more or less tended to compensate for the difference in pressure. Accuracy was not seriously impaired by slight variation in time and pressure among various cloths and treatments. Once a sample was introduced no further handling was required until after the crease angle was measured. Simplicity of operation and accuracy of reproduction made the roller pressure instrument useful for both laboratory development and production control testing. (13)

The research Committee on the Durability of Finishes reported to the general research committee meeting of the American Association of Textile Chemists and Colorists on September 23, 1948 that over 100 Monsanto wrinkle recovery testers costing $15.00 each were in use, while only three American Cyanamid motor driven roller pressure machines, costing $150.00, were in use. It was agreed that both instruments were superior to the TBL method of checking crease resistance and that both should be checked against each other. It was hoped that this work would soon be completed for there was an urgent need for satisfactory standards of performance of crease resistant finishes in today's market but this, in turn, depended upon a satisfactory method of testing. (3)

Buck and McCord, in 1949, stated that the crease-resistance of textile fabrics should be related to the fiber characteristics and fabric construction. The type of fiber which made up the yarn and fabric had, perhaps, the greatest influence on the fabric's crease-resistance. In the case of rayon, the celluose fiber may have its long chain-like molecules well-aligned (crystallites) or it may have a random arrangement of the macro-molecules (amorphous). The ability of a rayon fabric to recover from a crease once the creasing force was removed, depended upon the ability of the fiber to recover from its position of strain. Fibers composed predominantly of molecules in crystalline orientation, such as are found in high-tenacity rayons produced by a stretching process, did not return to their former position when strain was released because the molecular chains had slipped over one another and formed new attractive forces to adjacent groups while in the strained position. On the other hand, fibers which contained a number of amorphous regions such as the normal or unstretched rayons were less susceptible to wrinkling, because during the time of strain, the only extension in the fiber was the realignment of the molecules to a position of better orientation with the fiber axis. (6)

Buck and McCord further point out that fiber diameter also influenced crease-resistance, in as much as the fibers with the largest cross section had the greatest bending and torsional rigidity with which to resist deformation. Moisture, too, has an important influence on the elastic properties of textile fibers. The extensibility and plasticity of fibers are increased with the absorption of water. Therefore, both creasing and crease recovery are markedly affected by atmospheric humidity.

In this same article, these authors claim that the elastic recovery of cellulosic fibers can be improved by creating chemical cross-linkages between cellulose molecules. The treatment of the cellulose with formaldehyde formed methylene bridges tie together adjacent molecules, with the result that extensibility of the fibers is reduced, but elastic recovery increased. For maximum crease-resistance fiber strain in the yarn construction should be at a minimum. Too high a twist causes fibers to reach their elastic limit quickly upon additional stress, while too low a twist increases the possibility of actual displacement of the fibers in the yarn when the cloth is creased. They found that coarse yarns which contain more fibers in a cross section and usually have less twist were more resistant to creasing than fine yarns.

They claim that the ideal fabric for maximum crease-resistance was thick, and of a complicated weave pattern which seems to increase its flexibility. (6)

Cameron observed that with the introduction of strong cross-bonds into viscose rayon fibers; it prevented the separation of molecular chains and less water was absorbed. It reduced the possibility of internal slipping resulting in a greater reversible elasticity at low loads, less plasticity or irreversible extension at higher loads and reduced plasticity for wet fibers. It also decreased the effective pore size in the amorphous regions making the penetration of the wet structure more difficult for materials with relatively large molecules such as dyes. When the viscose fiber was modified by a typical anti-crease treatment (15%), about 1% was active in forming definite cross-bonds and the remainder was deposited interstitially in the amorphous regions of the fiber. The resin of both categories was effective in modifying fiber properties. (7)

During 1949, two more laboratory methods for the determination of chlorine in textiles were introduced----with a spectrograph (25) and by titration. Due to length of time employed, both would be impractical for use outside the research laboratory. (2)

In 1950 Gagliardi and Nuessle noted that correlation of changes in fiber properties with changes in mechanical properties of modified cellulose fabrics had not heretofore received much attention. As a result there existed considerable misunderstanding in the industry about effects of wrinkle-proofing and stabilizing agents on fabric properties. One common belief was that the acid catalysts and the high temperatures used to react such agents in the fabric degraded the cellulose. The basis for this belief was in the tear strength and abrasion resistance tests of modified fabrics which were found lower than those of the untreated materials. They found that such changes resulting from normal resin treatments had little to do with cellulose degradation, either hydrolytic or oxidative. They concluded that the apparent damage to cellulose as exemplified by changes in abrasion resistance, tear strength and tensile strength (in some cases) was merely due to a manifestation of decrease in fiber extensibility. Increasing the elastic modulus by treatment with cross-linking reagents, produced fibers which had a lower capacity for energy absorption and yarns and fabrics which had reduced capacity for distribution of those stresses applied by tearing, ripping and high abrasive forces. Also, complete elimination of fabric shrinkage by any of the wrinkle-proofing and stabilizing agents produced excessive reduction in tear and abrasion resistance. (21)

In connection with the abrasion resistance of resin treated fabrics, the authors stated, as many others have previously, that abrasion machines bear only a slight relation to what is normally obtained in actual wear of clothing. In actual wear, small stresses are applied slowly over long periods of time, while an abrasion machine abrades a sample to complete destruction in a very short period of time by the application of very high repeated stresses. Moreover, during normal wear, strains produced in the fibers have a chance to be relieved, since the stress cycles are far apart. Therefore, the abrasion machine greatly exaggerates the reduction in abrasion resistance of fabrics treated with wrinkle proofing and stabilizing agents.

Recently, with the use of the more precise Shiefer Abrasion machine, which allows for testing at different stress applications, they observed that the difference between the apparent abrasion resistance of an untreated and resin treated fabric diminished as the rate of abrading was decreased. At very low stress applications the chemically modified fabric actually had higher abrasion resistance than the original untreated rayon sample. Thus it appeared, that at very low stresses, which simulate actual wear, reduction in fiber extensibility was no longer a major influence on abrasion. The increase in elastic recovery of fibers became more important. (21)

Latter, Gagliardi, Lempka and Nuessle in continuing

this study on the Schiefer abrasion machine abraded samples that had been soaked in water for one hour. It was noted that with increasing concentration of applied resin, the abrasion resistance in the wet state increased; that for an untreated rayon fabric, the wet abrasion resistance was actually much lower if the fabric was not allowed to dry during the test period; and that for resin-treated fabrics the abrasion resistance was several hundred percent higher than that of untreated samples when they were tested continuously wet. (20)

In 1950 Gagliardi and Gruntfest pointed out that in the finishing of fabrics intended to be crease-resistant, it is very important to maintain a multifilament character in the yarn in order to obtain high crease recovery. If finishing treatments were applied which tended to cement fibers together by the disposition of surface materials, the fabric so treated not only would not be crease-resistant, but it would actually have a crease-recovery value much lower than that of the untreated sample. (19)

In June 1950 Nuessle and Bernard reported the effect of chlorination and ironing variables on the chlorine retention and tensile strength of fabrics previously treated with urea-formaldehyde, melamine-formaldehyde, methylated melamine-formaldehyde or a modified urea-formaldehyde. They found the concentration of the hypochlorite bath, the bath ratio (weight of solution per unit weight of fabric) and the type of resin treatment had considerable bearing on the quantity of chlorine retained by a resin-treated fabric. The modified urea-formaldehyde resin maintained a decided resistance to overdoses of chlorine, although it did retain a small amount of chlorine even after very mild bleaching. (36)

At the end of the year some of the fabrics treated with urea and melamine-formaldehyde resins were still, on occasions, developing unpleasant odors under a variety of conditions. The odors were described as fishy,rancid, glue-like, or just unpleasant. Development usually occurred in the summer time during hot, humid weather and were noticed months after the treated fabric was said to be odor free. Therefore, Linton Fluck of the American Cyanamid Company charted the per cent of urea to be used in resin application depending upon the formaldehyde resin solids in solution. These tabulations, based on the results of a great many experiments, prevented the development of odors without modifying the desired finish. (16)

And what is the future of the resin treated viscose rayon and acetate materials? A spokesman for Union Carbide stated there are hundreds of fibers that researchers are thinking about. There are scores in the test tubes, and dozens in the experimental stage being made into pound lots. Over the next few years there will be casualties among the synthetics. Rayon and acetate may get hurt. (59)

However, H. C. Borghetty stated that at the present point of development it appears that viscose, because of the low cost of its raw material, wood, easily surpasses all other synthetic fibers in quantity and will continue to do so for several years. (4)

Therefore, consumer acceptance as well as cost of materials determine the future of the resin-treated viscose rayon and acetate fabrics.

METHODS AND PROCEDURES

For this particular study eight different fabrics commonly seen in retail piece goods departments were chosen. Four were plain colored dress weight gabardines, the remaining four were light weight suitings widely used in both men's and women's ready-to-wear apparel. Two lengths of the dress weight gabardine in the "greige" were obtained from the converter. This made possible a comparison of the original "greige" with the original finished gabardines, and subsequently the differences in their performance characteristics. In Group I the gabardine dress fabrics differed in color only. In Group II the suitings differed in color and weave construction; although, as a group, all were variations of the twill weave.

This study is a part of a more comprehensive study of the Michigan State College Experiment Station. The coding was designed to differentiate between the sub projects of the overall project. The Roman numeral designates fiber content. The Arabic number indicates a specific fabric within a group. IA_1 through IA_4 constitutes the group of rayon dress weight gabardines. IA_5 is the gabardine in the "greige". IIA_1 through IIA_4 constitutes the group of suitings. See pages 181 to 185 for fabrics constituting Groups I and II.

Fabric specification analysis consisted of: chemical and microscopic fiber identification, determination of cost per square yard, weight per square yard, thickness and yarn count and weave structure. Yarn analysis included determination of yarn number, direction of twist and number of twists per inch.

Performance characteristics of the original fabrics as well as specimens withdrawn following the fifth, tenth and twentieth launderings and corresponding number of dry cleanings consisted of drapability, wrinkle recovery, compressibility, compressional resilience, wet and dry tensile strength and elongation, abrasion resistance and colorfastness to light. Weight per square yard, thickness, yarn count, dimensional change and colorfastness were similarly recorded and percent change calculated.

Test procedures conformed to the specifications of the American Society for Testing Materials Standards on Textile Materials, 1948, (1) under standard conditions of 65% ± 2% relative humidity and $70^{\circ} \pm 2^{\circ}$ Farenheit.

The chart on the following page summarizes the intervals at which the specific tests were performed.

In the appendix (pages 153 to 155) are to be found the cutting charts and specific allocation for sampling of test specimens. Plate XXV is the cutting chart for the dress weight gabardines, while Plate XXVI is for the group of suitings. Plate XXVII (Figures A and B) gives a more detailed illustration of sampling for the original, laundered and dry cleaned squares. From the original 12" x 12" squares, the sequence and order in which the tests were performed

CHART I
SUMMARY OF TESTING INTERVALS

	Original	After 1 *L.	After 1 **D.C.	After 2 *L.	After 2 **D.C.	After 3 *L.	After 3 **D.C.	After 5 *L.	After 5 **D.C.	After 10 *L.	After 10 **D.C.	After 20 *L.	After 20 **D.C.
1-Fiber Identification	X												
2-Cost/sq. yard	X												
3-Weave Structure	X												
4-Weight/sq. yard	X							X	X	X	X	X	X
5-Thickness	X							X	X	X	X	X	X
6-Yarn Count	X							X	X	X	X	X	X
7-Yarn no. or size	X												
8-Twist per inch	X												
9-Drapability	X							X	X	X	X	X	X
10-Wrinkle Recovery	X							X	X	X	X	X	X
11-Compressibility	X							X	X	X	X	X	X
12-Compressional Resilience	X							X	X	X	X	X	X
13-Tensile Strength (wet & dry) and Elongation	X							X	X	X	X	X	X
14-Abrasion Resistance	X							X	X	X	X	X	X
15-Colorfast to Light	X							X	X	X	X	X	X
16-Dimensional Stability		X		X		X		X	X	X	X	X	X
17-Colorfastness		X		X		X		X	X	X	X	X	X

* Laundering
** Dry Cleaning

were drapability, wet and dry tensile strength and elongation, wrinkle recovery, thickness, compressibility and compressional resilience. The laundered and dry cleaned squares (cut 15" x 15" to allow for shrinkage) were trimmed upon their withdrawal to the 12" x 12" specimens of the original sampling. For each withdrawn specimen the same sequence of testing was followed.

Due to the fact that sufficient yardage of the "greige" goods could not be obtained for complete testing; drapability, wet and dry tensile strength and elongation, and abrasion resistance after the tenth laundering and dry cleaning were, of necessity, omitted.

TESTING PROCEDURES

FIBER IDENTIFICATION

Verification of fiber content was determined by microscopic analysis, burning, acetone and fiber identification stain tests.

COST PER SQUARE YARD

The cost per square yard of each fabric was determined by the following formula:

$$\frac{36'' \times 36'' \times \text{cost of the fabric per running yard}}{36'' \times \text{width of fabric in inches}} = \text{cost per square yard}$$

WEAVE STRUCTURE

This was predetermined with the use of a hand lens before purchase for all fabrics selected for the study.

Subsequently the weave construction was analyzed and graphed.

WEIGHT PER SQUARE YARD

The Becker Chainomatic Analytical Balance was used to determine the weight per square yard. (14) Five specimens (2" x 2") from each control fabric with no two squares having the same warp or filling yarns were conditioned for 24 hours before weighing. The total weight in grams of the five specimens was recorded. The following formula was used to determine the weight per square yard.

$$\frac{45.71 \text{ x grams}}{\text{area in inches}} = \text{ounces per square yard (27)}$$

The specimens withdrawn after 5, 10, and 20 launderings and dry cleanings respectively likewise contained the same warp yarns as those of the original weight samples (See appendix pages 153 and 154).

THICKNESS

The thickness of the fabrics was computed with the Schiefer Compressometer (48) to the nearest .0005 inch. Standard thickness, which is the thickness of the fabric when the pressure upon it is one pound per inch^2 for ten seconds; was used as the basis for comparison. Nine determinations, corrected for zero reading of the compressometer, were averaged to calculate the original thickness of the fabrics as well as thickness at each withdrawal.

YARN COUNT

A Lowinson micrometer was used to count the number of yarns in an inch. (1) In both the warp and the filling the yarn count was recorded as the arithmetical average of five determinations with no two areas including the same set of yarns.

YARN NUMBER OR SIZE

The yarn number for the spun rayon yarns and the denier for the filament yarns were read directly on the Universal Yarn Numbering Balance. (55) For the spun rayons, which are based on the number of 840 yard hanks per pound, a 36" yarn length was weighed, while for the filament yarns (based on 450 meters of 1 denier weighing .05 gram), a yarn 90 centimeters in length was weighed. The yarn number or denier recorded was the average of 10 determinations each for warp and filling.

TWIST PER INCH

The Alfred Suter Twist Tester was used to determine the number of twists and direction of twist in both the warp and the filling yarns. (54) The following procedure was employed. For single yarns of spun rayon a 10 inch gauge length with a 3 gram deflection load was used. The yarn was completely untwisted and then retwisted to its original length which recorded twice the number of twists on the counter for the 10 inches tested. Therefore, this result was divided by (2 x 10) or 20 to obtain the average number of turns per inch. An average of the 10 determinations was recorded as twist per inch.

For ply yarns the 10 inch gauge and 3 gram deflection load were again used. The twist was completely removed by twisting the yarn in the direction opposite that of the original twist. In order to determine the complete removal of twist, a needle was inserted between the plies at the left jaw and moved to the right jaw. The total number of turns was then divided by 10 for determination of the number of twists given the two singles comprising the ply yarn. An average of ten determinations was calculated and recorded as twist per inch for the ply.

The twist of each single component yarn in the ply was done separately. While they were in parallel position the single not being tested was clipped. A gauge length of 5 inches and a deflection load of 3 grams were used in determining the number of turns per inch for each of the yarns in the ply. For single yarns of spun rayon, the yarn was untwisted and then retwisted to its original length with the counter result divided by twice the length of the yarn employed. For the filament yarns, a five inch length was twisted to rupture; a second yarn was untwisted and again retwisted until ruptured. (42) The following formula was used in determining the twist for filament yarns:

$$N_2 - N_2 = 2T$$

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

in which:

N_2 = Number of turns (twisted) 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

DRAPABILITY

In 1947 John H. Skinkle and Arthur J. Moreau devised a simplified and sensitive variation of the "Drapemeter", which had been developed some years previously for the measurement of "drape" or "handle" of cloth. (51) This simplified form was used in determining the drapability values of the fabrics in this study. The apparatus consisted of a ringstand and horizontal rod from which hung a 2½" paper clamp and a second ringstand with a clamp holding a millimeter rule. This rule was fixed in position 100 millimeters below the jaws of the paper clamp. The fabric specimen to be evaluated was cut 100 x 250 millimeters with the short dimension parallel to the set of yarns being evaluated. The specimen was folded back on itself with the face of the fabric on the convex side, and the clamp attached about ¼" below the top edges of the fabric. The fabric and clamp were then suspended from the rod and allowed to hang for 2 minutes. The millimeter scale was moved to the concave side with the scale touching the two edges of the fabric. The distance across the straight line connecting the edge was read in millimeters and recorded as the chord length. Since the sample was 100 millimeters in width, the direct reading was likewise a percentage of its width. Three determinations each were made on the warp and filling.

The arithmetical average for each set of yarns was then determined and the stiffness of the fabric computed as the geometric mean of the warp and filling (square root of warp times filling).

WRINKLE RECOVERY

The Monsanto Wrinkle Recovery Tester was used to measure the fabric's crease resistance or recovery from wrinkling. (31) Five test specimens each (1.5 cm. wide and 4 cm. long) were cut from the warp and filling, with the longer dimension representing the direction of test. A specimen holder composed of two thin metal leaves of different lengths was used for creasing. After conditioning four hours, the test specimen was placed between the metal leaves of the specimen holder with one end flush with the longer metal strip. The exposed end was turned back to the horizonal guide line indicated on the shorter leaf. Care was taken during this manipulation to allow no moisture from the fingers to get on the area to be creased. The metal holder with the specimen looped back was then inserted into the plastic press. With the flat, thicker side of the press adjacent to the fabric specimen, the press was closed. This creased the fabric about one-sixteenth of an inch beyond the end of the shorter leaf. The press-holder containing the specimen was placed flat on the table and a load of one and one-half pounds then applied to the platform for five minutes. The press was next unloaded and the metal holder with the fabric removed and subsequently mounted on the

Tester. The holder was pushed against the outer edge of the shelf of the movable disc and the crease of the fabric aligned with the vertical center line on the outer disc. The dangling leg of the fabric was kept aligned with this vertical guide line by periodic adjustments for a five minute period. The fabric recovery value was read directly from the calibrated scale on the movable disc. Averages of values for the five specimens each for warp and filling were calculated and recorded as the wrinkle recovery value.

COMPRESSIBILITY

The compressibility of a fabric is the ratio of the rate of decrease in thickness at a pressure of 1 pound per inch^2 to the standard thickness. Compressibility determinations were made on the Schiefer Compressometer. (48) For determining compressibility the following formula was used:

$$\frac{\text{thickness at 0.5 pound pressure per inch}^2 - \text{thickness at 1.5 pound pressure per inch}^2}{\text{standard thickness}} = \text{compressibility}$$

COMPRESSIONAL RESILIENCE

The compressional resilience of a fabric is the amount of work recovered by the fabric when the pressure is decreased from 2.0 to 0.1 pound per inch^2 and expressed as a percentage of the work done on the fabric when the pressure is increased from 0.1 to 2.0 pound per inch^2, as measured on the Schiefer Compressometer. (48) With this instrument simultaneous readings of thickness and pressure were taken at pressures 0.1, 0.2, 0.35, 0.5, 0.75, 1.0, 1.5, and 2.0

pounds per $inch^2$ and work done was computed by means of the formula $W = 0.025 (6A + 5B + 6C + 8D + 10E + 15F + 20G - 70H)$ where A, B, C, D, E, F, G, and H are the thickness in inches at the above pressures, respectively. The same formula constitutes the work recovered when the thicknesses from recovery were substituted. Nine recordings for each of the above thicknesses were averaged. Thus;

$$\frac{\text{Recovery Value}}{\text{Compression Value}} = \text{Compressional Resilience in Percent.}$$

BREAKING STRENGTH

Breaking strength was determined by the raveled-strip method on the Scott Tensile Strength Machine in accordance with standard test procedure of the A. S. T. M., 1948. (1) Twelve specimens were cut one and one-quarter inches in width and twelve inches in length, six having their longer dimension parallel to the warp yarns and the other six having their longer dimension parallel to the filling yarns. Each was raveled to one inch in width by taking from either side approximately the same number of yarns. The specimen was then cut into two six inch strips---one for the dry tensile strength test; the other broken after complete immersion in tap water for a twenty-four hour period. No two specimens cut for warp or filling breaking strengths contained the same warp or filling yarns, (See appendix page 155). The jaws of the machine placed three inches apart, had faces measuring one by one and one-half inches with the longer dimension perpendicular to the direction of load application. The average of six breaks on the dry warp were reported as the warp dry breaking strength, and similarly for warp wet tensile strength; and wet and dry filling strength. All recordings were made to the nearest half pound.

ELONGATION

Fabric elongation was obtained by an autographic recording attachment on the Scott Tensile Strength Machine simultaneously to the determination of breaking strength. (1) The elongation was an average of the results obtained for six specimens, and was expressed as the percentage increase in length.

ABRASION RESISTANCE

Resistance to abrasion was determined on the Taber Abraser. (56) Five specimens 5" x 5" from the original fabrics and subsequently from fabrics withdrawn after they had been laundered 5, 10, and 20 times and after comparable dry cleanings were selected (See appendix, Plate XXV and XXVI)...

Three of the five specimens were abraded for determining first signs of wear, which was arbitrarily defined as the first yarn broken, and hole defined as the breaking of two yarns at right angles to each other. After these determinations were completed for each fabric at each of the testing intervals, a constant number of cycles was established in abrading the remaining specimens. This constant number of cycles was arbitrarily determined; falling within the maximum and minimum range of cycles for first sign of appreciable wear and complete breakdown for all fabrics within the group. Testing was done using CS-10 calibrase wheels, under a 500 gram wheel pressure at standard conditions.

COLOR FASTNESS TO LIGHT

Colorfastness to light was determined with the Atlas Fade-Ometer. Specimens were subjected to light exposure for periods of 10, 20, 40, and 80 hours respectively and reported as colorfast to light according to the classification in Commercial Standard CS59-44. (8)

DIMENSIONAL STABILITY

Specimens, cut 15" x 15", were stitched around the outside edges to prevent fraying during subsequent launderings or dry cleanings. For identification, a white fabric two inches square with pertinent information indicating fabric code, time of withdrawal, and direction of test, etc., was basted at the upper left hand corner of each test specimen. Established points for dimensional stability measurements on fabrics to be withdrawn after the twentieth laundering and corresponding dry cleaning were basted warp wise and filling wise on the dark fabric specimens and marked with indelible ink on the light colored fabrics. Five markings, two and one-half inches apart, were made in both the warp and filling directions. Because two 15" x 15" squares were laundered twenty times and two similarly dry cleaned, ten determinations each in the warp and filling directions were recorded to the nearest 1/16" after the first, second, third, fifth, tenth and twentieth launderings and after the fifth, tenth and twentieth dry cleaning. The average of the five measurements recorded for both warp and filling on the specimens at designated periods was recorded as the change in inches and percentage change calculated.

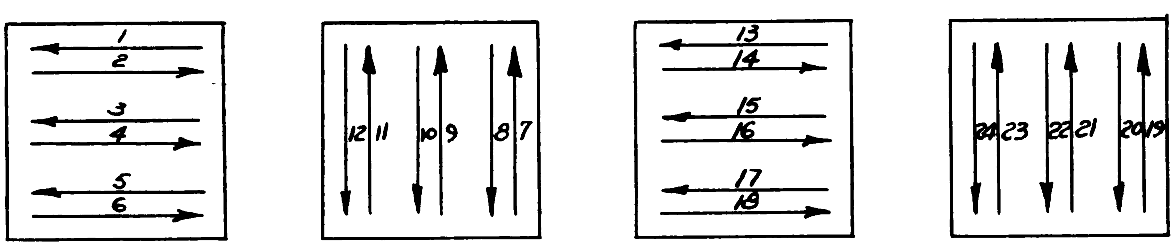
LAUNDERING PROCEDURE

The specimens were laundered in an Atlas Launder-Ometer. Into each jar was placed one 15" x 15" specimen, five 3" x 3" weight squares, or five 6" x 6" abrasion squares, all previously edge stitched to prevent fraying. Throughout the procedure the amount of liquid in the jar was ten times the weight of the specimens laundered. Each sample plus ten steel balls, (one quarter inch in diameter), and Tide (the ratio of one quarter teaspoon of detergent to three hundred cubic centimeters of water) were placed in pint jars previously heated to 105° F. The jars were capped, placed in the Launder-Ometer tank and rotated for fifteen minutes. The samples were then removed, placed in a fresh Tide solution and the complete procedure repeated for another fifteen minutes. The jars were emptied and the samples were rinsed in clear water of the same temperature. After rotation for ten minutes in the Launder-Ometer tank, they were emptied and added to a jar of clear water at a temperature of 80° F. The jars were shaken vigorously and allowed to stand for

ten minutes. The specimens were then given a third rinsing in a jar of cold water; removed, squeezed gently, and rolled in a towel for ten minutes.

PRESSING PROCEDURES

All samples were pressed on a padded board with a $3\frac{1}{4}$ pound Hoover dry iron. The 20" x 20" board was padded with two layers of thin turkish toweling over which there was a covering of washed unbleached muslin. The fabric with the right side up, was smoothed out with the palms of the hands to avoid stretching or distortion. A chemically treated press cloth was placed over the material and the ironing strokes were made with minimum pressure. The movement of the iron can be seen below.



When the smaller pieces were pressed, they were placed side by side; so that the grain of each specimen coincided with the movement of the iron. As many specimens as could be placed on the board at one time were pressed according to the above procedure.

It was necessary to make twenty-four movements with the iron for acceptable appearance of the gabardine fabrics of Group I. Therefore, all fabrics in the study were subjected to the same amount of pressing.

The fabrics were then carefully placed on a flat surface and allowed to dry twenty-four hours before being measured for dimensional change. For each fabric in the study two 15" x 15" squares, five 3" x 3" weight squares and five 6" x 6" abrasion squares were withdrawn for testing after the fifth, tenth and twentieth launderings.

DRY CLEANING PROCEDURE

The fabrics were dry cleaned and pressed in a commercial establishment in East Lansing. All specimens to be tested for a specified number of dry cleanings were stitched together for ease in handling. A petroleum base cleaning fluid was used. The fabrics constituted a part of a regular cleaning load and were pressed with a steam presser. Specimens were withdrawn for testing following the fifth, tenth and twentieth dry cleaning.

COLORFASTNESS TO LAUNDERING AND DRY CLEANING

A two inch square of white test cloth was sewed to each 15" x 15" specimen to be laundered or dry cleaned. Subjective comparison with the control fabric was made after each of the first five, the tenth, and twentieth laundering and after the fifth, tenth and twentieth dry cleaning.

INTERPRETATION OF RESULTS

ANALYSIS OF FABRIC SPECIFICATIONS

Group I

In analyzing the dress weight gabardines, acetate and viscose fibers were identified in both the warp and filling yarns (See Table I, page 51). Ross and Oberleder Fabrics Corporation, the converters, stated these fabrics to be 50 per cent acetate staple and 50 per cent rayon staple. The weave construction was an uneven, warp-face twill with the filling yarns under two and over one end (See Plate XXVIII in the appendix).

Significant weight differences among the four gabardine fabrics showed the pink (number 1), to be approximately .15 of an ounce per square yard lighter than the yellow (number 2) or brown (number 3), while the forest green fabric (number 4) was heavier than the other three. The greige goods weighed less per square yard than any of the finished fabrics. The greige goods, according to the converter, are given "full shrinkage" (usually 10 to 12 per cent) depending upon the color of the subsequent dyeing. More shrinkage occurs in dyeing dark shades than lighter colors. This probably accounts for the differences in the weights of the finished gabardines.

The standard thickness of each finished fabric paralleled its weight per square yard. In order of thickness the pink fabric was lowest, then yellow, brown and the forest green, which was .002 inch thicker than the pink. Although the greige material was lighter in unit weight than the finished gabardines, it was thicker than the two light colored fabrics but less thick than the other two.

TABLE I

FABRIC ANALYSIS OF THE DRESS WEIGHT GABARDINES

Fabric	Fiber Identification Warp	Fiber Identification Filling	Thickness (1)	Weight Per Square Yard	Yarn Count(2) Warp	Yarn Count(2) Filling
IA_1 Pink	Acetate Viscose	Acetate Viscose	.0199"	5.5683 ounces	111 per inch	56 per inch
IA_2 Yellow	Acetate Viscose	Acetate Viscose	.0206"	5.7176 ounces	109 per inch	56 per inch
IA_3 Brown	Acetate Viscose	Acetate Viscose	.0215"	5.7366 ounces	110 per inch	55 per inch
IA_4 Green	Acetate Viscose	Acetate Viscose	.0219"	5.9229 ounces	109 per inch	55 per inch
IA_5 Greige	Acetate Viscose	Acetate Viscose	.0210"	5.2994 ounces	106 per inch	52 per inch

(1) Average of 9 determinations.
(2) Average of 5 counts.

The warp yarn count of the treated specimens was twice that of the filling which indicates a poor balance in weave structure. The warp and filling yarns were of similar size, with the warp slightly finer than those of the filling (See Table II, page 52).

The filling yarns for the four fabrics in this group showed variation in both size and amount of twist. The filling yarns in the dark green (number 4), were coarser than those of the pink (number 1), or brown (number 3), or yellow (number 2). The filling yarns of the greige fabric were approximately the same as two of the finished fabrics (numbers 1 and 3).

TABLE II

YARN ANALYSIS OF THE DRESS WEIGHT GABARDINES

Fabric	Yarn Number (1) Warp	Yarn Number (1) Filling	Twist Per Inch (1) Warp	Twist Per Inch (1) Filling
IA_1 Pink	Spun 22.7	Spun 20.4	S twist 18.0	Z twist 17.8
IA_2 Yellow	Spun 21.2	Spun 22.1	S twist 19.3	Z twist 18.8
IA_3 Brown	Spun 21.3	Spun 20.2	S twist 19.1	Z twist 16.9
IA_4 Green	Spun 21.4	Spun 18.5	S twist 19.3	Z twist 17.1
IA_5 Greige	Spun 21.2	Spun 20.6	S twist 15.0	Z twist 16.4

(1) Average of 10 determinations each in warp and filling

All warp yarns were of S twist, with approximately the same number of twists per inch in each of the four fabrics. The Z twist filling yarns, on the other hand, showed a variance of two turns per inch in twist. The twist in the warp yarns in the greige fabric was three turns lower than yarns in the finished gabardines.

Each of the fabrics of Group I measured approximately 41.5 inches in width and the computed cost per square yard was $.86.

The exact finish applied to the fabric was not revealed by the converters, although they indicated that the fabric had been given a resin process more costly than an ordinary finish and helped give the fabric a little more crease resistance. They made no specific claim concerning the effectiveness or permanence of the finish.

Group II

Each of the suitings had both acetate and viscose yarns in warp and filling. The grey, white and orange yarns were acetate, while the black and brown yarns were viscose rayon.

Three variations of twill weave comprised the fabrics in Group II (See Plates XXIX and XXX in the appendix). Suiting number one was an even warp-face twill of 2/2 construction with grey and brown yarns alternating in both warp and filling. The weave of fabric two was identical in construction to fabric one, but the alternating yarns in both directions were black and white. Number three was a combination even 2/2 twill and herringbone weave. Number four was a modified twill weave, incorporating black, white and orange yarns to form a check.

Variance in the weights of the Group II fabrics was within .5 ounce per square yard (See Table III, page 54). It is of particular interest that the heaviest and lightest fabrics were of the same weave construction.

The thickness of the individual fabrics did not parallel their weight per square yard. Each fabric varied approximately .001 inch from an average thickness. This variation may be explained by differences in yarn size and yarn count. Fabric number two, was the thickest and also heaviest. Fabric number four, was second in thickness and weight.

Fabric number one, ranked third in thickness but lowest in weight.

TABLE III

FABRIC ANALYSIS OF THE SUITINGS

Fabric	Fiber Identification Warp	Fiber Identification Filling	Thickness (1)	Weight Per Square Yard	Yarn Count(2) Warp	Yarn Count(2) Filling
IIA_1 Brown Grey Twill	Viscose Acetate	Viscose Acetate	.0238"	6.6236 ounces	79 per inch	60 per inch
IIA_2 Black White Twill	Viscose Acetate	Viscose Acetate	.0259"	7.1573 ounces	80 per inch	65 per inch
IIA_3 Brown White Herringbone	Viscose Acetate	Viscose Acetate	.0228"	6.7191 ounces	80 per inch	60 per inch
IIA_4 Black White Orange Check	Viscose Acetate Acetate	Viscose Acetate Acetate	.0249"	6.9687 ounces	80 per inch	63 per inch

(1) Average of 9 determinations
(2) Average of 5 counts each in warp and filling

Variation in yarn count in the fabrics is explained by the fact that in each fabric the denier and yarn size varied. These variations compensate to some extent for the differences in yarn count. Because of the difference in the yarn structure as well as in the weave structure, the weight of the individual fabrics would necessarily show similar variation. The number of warp and filling yarns for the fabrics in this group was designed to achieve texture, color and pattern interest. Performance testing showed them to be well balanced.

It can be seen from Table IV, page 56 that the singles constituting the ply were of both spun and filament yarns constructed to compensate for each other. The finer the group of filaments, the larger was the size of the spun yarn and vice versa. In fabric four, the orange yarns were singles composed of filaments only, which were approximately twice the denier of the singles of filaments used in the two-ply yarns. They looked the same size as the ply yarns when woven.

The direction and amount of twist for the singles (See Table V, page 57) in each of the fabrics were similar. This was also true in combining the two singles into a ply yarn. An exception was noted in the filament singles, for the dark colors (black and brown) had been given the Z twist while the white and grey filaments in the single yarns were given a slightly higher amount of twist and twist in the opposite direction. The (orange) singles in fabric four, although unlike the other yarns, had a balanced amount of twist in warp and filling.

The width of the fabrics in Group II was approximately sixty inches and $1.79 was computed as their cost per square yard. "Colonial Mills, Inc., New York" was the only identification on the tags attached to each length of material. The yard goods department from which they were purchased stated the fabrics had been treated for crease resistance.

TABLE IV
YARN NUMBER OF THE SUITINGS

Fabric	Warp			Filling		
IIA_1	Brown Filaments 112 denier --- Spun 23	Grey Filaments 101 denier --- Spun 26		Brown Filaments 112 denier --- Spun 21.5	Grey Filaments 100 denier --- Spun 24.3	
IIA_2	Black Filaments 116 denier --- Spun 21.3	White Filaments 100 denier --- Spun 25.4		Black Filaments 118 denier --- Spun 23.0	White Filaments 103 denier --- Spun 24.5	
IIA_3	Brown Filaments 112 denier --- Spun 22.9	White Filaments 100 denier --- Spun 26.0		Brown Filaments 114 denier --- Spun 23.0	White Filaments 100 denier --- Spun 23.8	
IIA_4	Black Filaments 116 denier --- Spun 20.9	White Filaments 103 denier --- Spun 24.9	Orange Filaments 207 denier	Black Filaments 120 denier --- Spun 20.9	White Filaments 96 denier --- Spun 25.6	Orange Filaments 211 denier

Each is an average of 10 determinations

TABLE V
TWIST PER INCH OF THE SUITINGS

<table>
<tr><th>Fabric</th><th colspan="3">Warp</th><th colspan="3">Filling</th></tr>
<tr><td>II_1</td><td>Brown
2 ply-S twist
15.2
Singles
Fila-ments Z twist: 2.1
Spun Z twist: 16.2</td><td>Grey
2 ply-S twist
15.0
Singles
Fila-ments S twist: 2.8
Spun Z twist: 15.8</td><td></td><td>Brown
2 ply-S twist
14.9
Singles
Fila-ments Z twist: 2.5
Spun Z twist: 18.4</td><td>Grey
2 ply-S twist
15.1
Singles
Fila-ments S twist: 2.9
Spun Z twist: 17.2</td><td></td></tr>
<tr><td>II_2</td><td>Black
2 ply-S twist
15.4
Singles
Fila-ments Z twist: 2.4
Spun Z twist: 16.6</td><td>White
2 ply-S twist
15.0
Singles
Fila-ments S twist: 3.7
Spun Z twist: 16.1</td><td></td><td>Black
2 ply-S twist
15.1
Singles
Fila-ments Z twist: 2.3
Spun Z twist: 18.2</td><td>White
2 ply-S twist
15.0
Singles
Fila-ments S twist: 2.9
Spun Z twist: 16.3</td><td></td></tr>
<tr><td>II_3</td><td>Brown
2 ply-S twist
15.4
Singles
Fila-ments Z twist: 2.2
Spun Z twist: 16.8</td><td>White
2 ply-S twist
15.1
Singles
Fila-ments S twist: 4.1
Spun Z twist: 16.3</td><td></td><td>Brown
2 ply-S twist
15.3
Singles
Fila-ments Z twist: 2.5
Spun Z twist: 19.6</td><td>White
2 ply-S twist
14.5
Singles
Fila-ments S twist: 3.2
Spun Z twist: 18.3</td><td></td></tr>
<tr><td>II_4</td><td>Black
2 ply-S twist
15.0
Singles
Fila-ments Z twist: 2.1
Spun Z twist: 17.1</td><td>White
2 ply-S twist
15.2
Singles
Fila-ments S twist: 3.8
Spun Z twist: 16.7</td><td>Orange
Filaments
S twist
8.9</td><td>Black
2 ply-S twist
15.2
Singles
Fila-ments Z twist: 3.1
Spun Z twist: 18.1</td><td>White
2 ply-S twist
15.1
Singles
Fila-ments S twist: 1.7
Spun Z twist: 17.1</td><td>Orange
Filaments
S twist
9.5</td></tr>
</table>

Each is an average of 10 determinations

A COMPARISON OF THE FABRIC SPECIFICATION ANALYSIS FOR GROUPS I AND II

Each of eight fabrics in this study was of twill weave. The weave construction in the four fabrics of Group I was an uneven, warp-face twill while three variations of the twill weave comprised Group II. Two fabrics in this group were warp-faced twills, a third was a herringbone twill, while the fourth was a combination of even and uneven twill.

The suitings averaged 1.1 ounces per square yard heavier and .003 of an inch thicker than the dress weight gabardines. The fabrics of Group II were more balanced in yarn count than the gabardines. Because of the unlike number of yarns in the warp and filling, the gabardines tended to be easily distorted in shape. On the other hand, the suitings, which had an almost equivalent count in warp and filling were firm, of smooth hand, good body and weight.

The Group I fabrics were woven of single spun yarns, which were a blend of viscose and acetate staple. The group of suitings were woven of two ply yarns in both warp and filling. Each ply yarn was made of one single yarn of filaments with very low twist and a single of spun rayon. In every case the ply yarn was either all acetate or all viscose depending upon the color. The white and grey yarns were acetate while the brown and black were viscose. The orange yarns of IIA_4 were acetate and contained only filaments.

The average price per square yard of the gabardines was $.86 while the twill suiting was $1.79 per square yard. Each of the eight fabrics had been given a treatment including a functional finish for crease resistance. In neither group of fabrics was the method of application revealed. In Group I no statement was made by the converter concerning the degree of crush resistance or permanency of the finish. No specific guarantee of crease-resistance or its permanency was made in respect to the suitings.

PERFORMANCE OF THE ORIGINAL FABRICS

Group I

The Group I fabrics were purchased as identical except in color. In specification analysis of these four fabrics it was evident that they were not the same, for within this group there were differences in weight, thickness, yarn count, yarn size and amount of twist. Thus, the performance of the different fabrics could not be expected to be identical for any specific test.

The drapability values of these four specimens were similar (See Table VI, page 61). The brown (number 3) fabric was the lowest in drapability while the yellow (number 2) was the best. The untreated or greige fabric was expected to be resistant to draping because of the warp sizing it contained. However, due to a supple filling, its drapability was greater than the average of the treated fabrics.

The warp wrinkle recovery values of the dress weight rayon gabardines were lower than those in the filling. According to Powers, who stated that the recovery angle of a fabric must be 100 degrees as measured on the Monsanto Wrinkle Recovery Tester for the fabric to be commercially acceptable, neither the brown or green fabrics could qualify as commercially acceptable crease resistant fabrics because of their low warp recovery. (34) The other two did qualify as their values were 103 degrees and 109 degrees. The warp direction of the greige goods because of sizing applied for weaving recovered only to a small degree, while the filling showed acceptable recovery.

Compressibility or rate of compression in relation to fabric thickness was much higher for the green and brown specimens than the others in this group. These were the same two fabrics that had shown the least recovery from wrinkling in the direction of the warp. IA_1 and IA_2 compressed less readily and similarly had more acceptable recovery from wrinkling. The greige cloth compressed slowly and wrinkled badly. In this group of fabrics there was an inverse relationship between their rate of compression and amount of wrinkle recovery.

TABLE VI
PERFORMANCE OF THE ORIGINAL DRESS WEIGHT GABARDINES IN DRAPABILITY, WRINKLE RECOVERY, COMPRESSIBILITY AND COMPRESSIONAL RESILIENCE

Fabric	Drapability (1)	Wrinkle Recovery (2) Warp	Wrinkle Recovery (2) Filling	Compressibility (3) In.^{2} per lb.	Compressional Resilience in per cent (3)
IA_1 Pink	45	103	112	.0553	36.48
IA_2 Yellow	44	109	122	.0550	16.57
IA_3 Brown	47	95	119	.0619	43.70
IA_4 Green	45	96	115	.0623	35.03
IA_5 Greige	41	46	105	.0397	23.78
Average	45	101	117	.0586	32.94

*IA_5 not included in average
(1) The square root of warp x filling, each of which is the average of 3 determinations.
(2) Average of 5 determinations each in warp and filling.
(3) Average of 9 determinations.

The per cent of compressional resilience for the original fabrics was varied. In fact, they were so erratic that the average 32.94 per cent could not be considered as typical of the performance of any one of the four fabrics in the group. The ability of the yellow fabric to return to its original state was exceedingly poor when compared with the other three fabrics of the group. The greige, had less resilience than the pink, brown and green fabrics.

TABLE VII
PERFORMANCE OF THE ORIGINAL DRESS WEIGHT GABARDINE IN TENSILE STRENGTH (WET AND DRY) AND ELONGATION AND ABRASION RESISTANCE

	Tensile Strength in Pounds (1)				Elongation in per cent (1)				Abrasion Resistance(2)	
	Warp		Filling		Warp		Filling		**F.S.	
Fabric	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	of W.	Hole
IA_1 Pink	41.0	70.3	18.5	32.2	33.9	29.1	23.5	22.9	169	378
IA_2 Yellow	35.8	64.6	17.5	28.8	28.6	28.9	17.9	17.6	175	519
IA_3 Brown	40.1	61.9	20.6	34.5	35.4	28.9	21.8	21.6	226	493
IA_4 Green	38.2	60.5	24.2	41.8	36.3	33.1	23.1	18.8	193	532
IA_5* Greige	36.6	67.6	18.0	32.8	36.9	27.3	23.2	22.6	215	444
Average	38.8	64.3	20.2	34.3	33.6	30.0	21.6	20.2	191	480

*IA_5 not included in average
(1) Average of 6 determinations
(2) Average of 3 determinations
**F.S. of W.-First Sign of Wear

Fabrics three and four had lower warp (dry) breaking strength while fabrics one and two had lower (dry) filling strength. The pink fabric, containing a slightly finer warp yarn with fewer twists per inch had one yarn more per inch than the three other fabrics in this group and higher (wet and dry) warp tensile strength. In filling yarn counts, the four fabrics had a difference of only one yarn per inch. With this similarity in yarn count, the difference in yarn size may partially explain the higher filling (dry) breaking strength of number three and four. Fabric two which had the lowest breaking strength had the finest filling yarns with highest twist per inch. Fabrics one and three had a comparable number of somewhat coarser yarns than fabric two. Their filling strengths, which were within two pounds, averaged five pounds more than fabric two. Fabric four's filling yarns were coarser than the other three fabrics and no doubt contributed to its higher tensile strength. In each fabric the wet tensile strength was much less than dry strength. Based on the group average, the wet warp strength was approximately 40 per cent of the dry, while filling wet strength was approximately 59 per cent of dry strength. Both wet and dry breaking strength of the greige fabric approximated the warp and filling averages of the four finished fabrics in this group.

With one exception, the per cent elongation in both warp and filling was greater in wet strength determinations. The extent of elongation in each fabric was similar for both wet and dry breaking strength. Elongation in the greige goods was greater than the average elongation for the other fabrics in warp (wet) determinations and both wet and dry determinations for the filling.

The abrasion resistance of this group of fabrics for first sign of wear and a hole was low, three of the four showing first sign of wear at less than 200 cycles. Between the fabrics was a variation of 57 cycles. In each case it was a warp yarn which was broken in the recording for first sign of wear. The pink fabric had the lowest abrasion resistance. It may have been partially due to the use of finer and more loosely twisted warp yarns than those of the other fabrics. The yellow ranked third lowest in the group in abrasion resistance. It had yarns of comparable size and twist to fabrics three and four but was thinner and of lighter weight. The green and brown fabrics which were heavier and thicker had 18 to 51 more abrasion cycles for first sign of wear than the other two fabrics. Both the green and yellow fabrics required over 500 cycles to produce a hole. The pink abraded to a hole in 115 fewer cycles than the other three fabrics. The filling yarns of the green and brown fabrics deviated in that one had the coarsest filling yarns with the least amount of twist and the other had the finest yarns with the highest twist within the group.

The performance of the pink fabric (number 1) may have been modified by good resin application. According to Buck and McCord (6) fine yarns with their smaller diameter but of comparable twist per inch to heavier yarns have less resistance to creasing. Also, thicker fabrics tend to resist wrinkling. Moisture regain of rayon fabric can be reduced from the normal 11 per cent to 4 per cent by resin application. (12) A subsequent slight gain in dry tensile strength results. While the pink material was the thinnest and had the finest warp yarns of the group, its wrinkle recovery was good. Its warp tensile strength (both wet and dry) was slightly more than in the other three fabrics. This higher tensile strength and good wrinkle recovery indicate that the application of the resin finish may have been more effective in this fabric than in the other fabrics of the group.

The four fabrics in this group were Class 0 in their colorfastness to light. All had an appreciable color change after 10 hours exposure in the Fade-Ometer.

Group II

The ability of the brown and grey suiting (fabric number 1) to drape was somewhat superior to the other three suitings. (See Table VIII, page 66). The drapability values of the latter three were similar; namely, 57, 46 and 58 for fabric number two, three and number four respectively. Fabric one's somewhat superior drapability could be due to its lower yarn count, finer yarns, and lower weight per square yard.

This group of suiting fabrics had good initial recovery from wrinkling both warpwise and fillingwise. In spite of weave variation and unbalanced yarn count each of the four fabrics had consistent wrinkle recovery values of 140 or more in both the warp and filling. Because values are relatively equivalent in both warp and filling directions, the garments made from them would recover similarly regardless of the area creased. Fabric number two which had the highest wrinkle recovery value was also the heaviest, thickest and had the highest yarn count per inch in both warp and filling.

TABLE VIII
PERFORMANCE OF THE ORIGINAL SUITINGS IN
DRAPABILITY, WRINKLE RECOVERY, COMPRESSIBILITY AND
COMPRESSIONAL RESILIENCE

Fabric	Drapability (1)	Wrinkle Recovery (2) Warp	Filling	Compressibility(3) $In.^2$ per lb.	Compressional Resilience in Per cent (3)
IIA_1 Brown/Grey Twill	50	145	150	.0604	26.75
IIA_2 Black/White Twill	57	148	150	.0554	30.39
IIA_3 Herringbone Twill	56	140	145	.0599	28.45
IIA_4 Check	58	141	152	.0629	24.98
Average	55	144	149	.0596	27.64

(1) The square root of warp x filling, each of which is the average of 3 determinations.
(2) Average of 5 determinations.
(3) Average of 9 determinations.

The rate of compression was highest for fabric number four. Number one was second, while three and two ranked third and fourth in their compressibility. Fabric number two was lowest in compressibility, highest in recovery from wrinkling as well as one of the two stiffest fabrics in the group. The check material (number 4), which compressed so rapidly had excellent recovery from wrinkling in the filling but considerably less recovery in the warp direction. This material was a variation of a warp-face twill weave. Weave structure may account for this higher compressibility and lower recovery from wrinkling in the warp. Fabric number three did not compress as readily as one or four and showed less ability in recovering from wrinkles than either fabric one or four.

The compressional resilience of the four fabrics comprising this group was noticeably similar. In all cases compressional resilience paralleled rate of compression; the faster the material flattened the less ability it had to return to its original state. The black and white twill (fabric number 2) had 30 per cent recovery after compression, with the herringbone (fabric number 3), brown and grey twill (fabric number 1) and check (fabric number 4), of 25 per cent recovery following in this order of compressional resilience.

The warp (dry) tensile strength for fabric one was noticeably less than that of the other three fabrics in this group (See Table IX, page 68), although it contained only one less warp yarn per inch. The other three fabrics with 80 yarns per inch in the warp each had a tensile strength of approximately 73 pounds. This would indicate equalized warp yarn structure for fabrics two, three and four. In all cases wet breaking strength was consistently lower than dry. The wet breaking strength of the warp was approximately 58 per cent of the dry strength.

Filling breaking strength (dry) was approximately 20 pounds lower than warp breaking strength (dry). Fabrics one, three and four broke at approximately the same number of pounds while fabric number two was five pounds higher. Wet-dry strength relationship was comparable to that of the warp.

TABLE IX
PERFORMANCE OF THE ORIGINAL SUITINGS IN TENSILE STRENGTH (WET AND DRY) AND ELONGATION AND ABRASION RESISTANCE

	Tensile Strength in Pounds (1)				Elongation in Per Cent (1)				Abrasion Resistance (2)	
	Warp		Filling		Warp		Filling		F.S.*	
Fabric	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	of W.	Hole
IIA_1 Brown/ Grey Twill	38.0	64.7	28.9	51.2	26.8	18.7	23.1	18.2	141	366
IIA_2 Black/ White Twill	43.0	73.3	32.5	55.9	25.6	18.7	22.8	18.7	308	454
IIA_3 Herring-bone	44.2	73.8	29.6	51.1	23.9	17.8	22.3	18.2	198	331
IIA_4 Check	41.5	73.2	29.1	49.2	22.3	17.6	20.6	16.9	304	345
Average	41.7	71.2	30.0	51.8	24.6	18.2	22.2	18.0	238	374

*F. S. of W. - First Sign of Wear
(1) Average of 6 determinations
(2) Average of 3 determinations

Just as the tensile strength performance in each direction of the fabrics was similar, so was the amount of elongation simultaneously recorded. The amount of elongation in warp and filling was almost equal; warp dry being 18.2 per cent and filling dry 18.0 per cent, while warp wet and filling wet were 24.6 per cent and 22.2 per cent respectively. The white yarns in the filling of IIA_4 were smaller and their filaments contained less twist per inch than the others in the group of fabrics. This may have caused the lower (dry) breaking strength and lower elongation of filling yarns.

The abrasion resistance of the group for first sign of wear was inconsistent. Fabrics one and three had 141 cycles and 198 cycles respectively, while fabrics two and four required 308 and 304 cycles before a yarn would break. In every case a warp yarn was broken for first sign of wear. The weight per square yard of the fabrics paralleled their first sign of wear; the lightest weight fabric having least resistance in yarn rupture. Fabric two, the heaviest, thickest and with the highest number of yarns per inch required a few more cycles before one yarn was broken, and needed approximately 100 additional cycles beyond the average of the other three fabrics before a hole appeared.

IIA_1 rated Class 2 (no appreciable change after 20 hours exposure in the Fade-Ometer) in colorfastness to light. IIA_2 and IIA_3 rated Class 3 (no appreciable change after 40 hours exposure), while IIA_4 as Class 4 showed no appreciable change after exposure of 80 hours in the Fade-Ometer.

A COMPARISON OF THE ORIGINAL FABRIC PERFORMANCE

The dress weight gabardines were 10 per cent higher in drapability than the suitings. The average for the Group I fabrics was typical of each of the four materials. However, this was not true in Group II. The brown and grey twill was more supple than the other three suitings and better than the average for the group in this characteristic.

The suitings were superior to the gabardines in wrinkle recovery. Their warp and filling averaged 43 and 32 degrees more than the corresponding averages for the gabardines.

The two groups of fabrics were similar in compressibility.

In compressional resilience the four suitings were comparable. The gabardines were erratic; three of them having better compressional résilience than the suitings, the fourth being decidedly inferior.

Both wet and dry breaking strengths for each suiting fabric was higher than the breaking strength for the gabardines. Unbalanced yarn count in the Group I fabrics resulted in greater differences between their warp and filling breaking strengths (wet and dry) than the suitings in Group II.

Filling elongation was similar in the eight fabrics tested. However, warp elongation for the gabardines was approximately 10 per cent greater than corresponding elongation in the suitings. Elongation in warp and filling was equivalent in the suitings.

Although average abrasion resistance for first sign of wear was higher in the suitings, the brown and grey twill recorded the lowest number of cycles for any of the eight fabrics. The gabardines showed a better performance when abraded to a hole.

An appreciable color change was seen in each of the gabardines after only 10 hours exposure in the Fade-Ometer. Colorfastness to light of the suitings was much better. The brown and grey twill was rated Class 2 which is qualified as follows: "Such textiles are considered satisfactory for use where moderate fastness to light is desirable but not of major importance." (8) Since three of the suitings were better than Class 2 this brown and grey twill may be said to have "moderate fastness to light." Group II fabrics may then be rated as having good colorfastness to light in consideration of their end-use.

FABRIC PERFORMANCE IN LAUNDERING AND DRY CLEANING

Group I

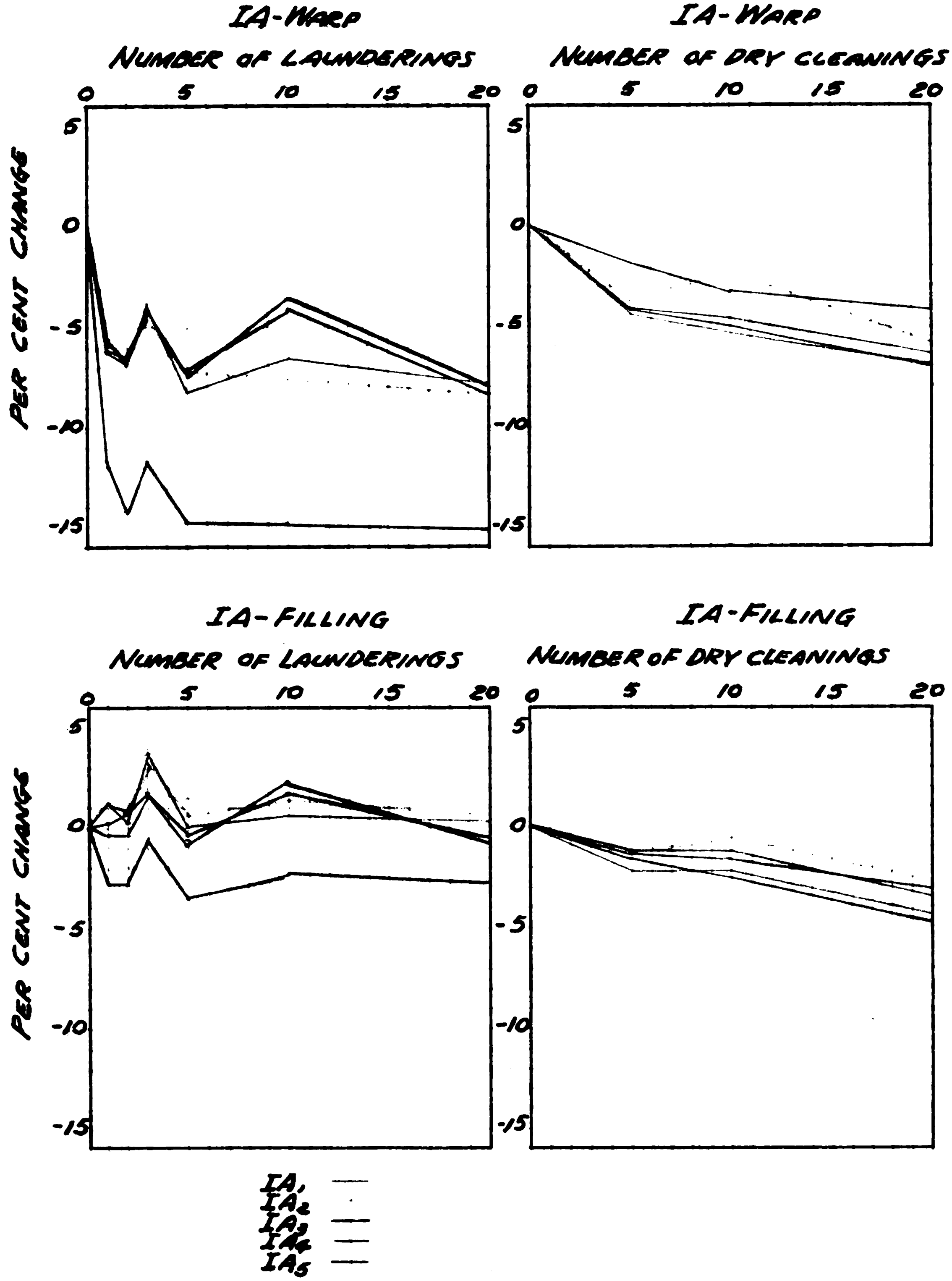
DIMENSIONAL STABILITY

When considering dimensional stability, this group of fabrics on the whole, displayed erratic behavior. There was considerable shrinkage in the warp of the dress weight gabardines after laundering and dry cleaning. In the filling, both stretchage and shrinkage occurred after successive launderings, but only shrinkage after dry cleaning. On the following page is a graph showing the effect of laundering and dry cleaning on the dimensional stability of the fabrics in Group I.

These fabrics would be totally unacceptable after any laundering for even after the first, the average warp shrinkage, which was typical of the group, was 5.88 per cent (See Table X in the appendix). Any attempt to stretch a garment with this amount (approximately 6 per cent) of shrinkage (equivalent to two or three inches) to its original dimensions would be very difficult. Even if original dimensions could be restored, it would present the problem of distortion in appearance. In the first laundering the filling of the pink and yellow fabrics stretched 1 per cent. Dimensional change for the other two fabrics was negligible.

The unpredictable behavior of these fabrics was significant. After the first two launderings the group, as a whole, shrank approximately 7 per cent in the lengthwise direction. When measurements were analyzed following the third

PLATE I
PERCENTAGE DIMENSIONAL
CHANGE



laundering, the shrinkage for the group was only 4 per cent. After the fifth laundering the 7.5 per cent average shrinkage was quite typical of the group. After the tenth laundering the individual fabrics presented such diversified shrinkage that the average warp-wise shrinkage could not be considered typical for the group. The two dark colors, brown and green, shrank 3.5 and 4 per cent while the pastel, pink and yellow, 6.5 and 7.5 per cent respectively. After the twentieth laundering, warp shrinkage was approximately 8 per cent for each of the fabrics. Dimensional change in the filling was negligible until after the third laundering. The stretchage in the gabardines ranged from 1.5 per cent in the brown to 4 per cent in the pink. After the fifth laundering, the dimensional change was under 1 per cent but at the tenth a 1.5 per cent stretchage was again recorded. By the twentieth, the averaged filling measurements approximated the average initial measurements. The greige goods in both warp and filling showed a much higher shrinkage than the treated specimens, which had been given a resin application for dimensional stability as well as wrinkle recovery.

After dry cleaning, these fabrics had shrunk 4, 5 and over 6 per cent in length after five, ten and twenty cleanings respectively. There was one exception--the yellow cloth. Its shrinkage was similar after the fifth dry cleaning, but only 2 per cent after the tenth instead of the 5 per cent average of the other three fabrics. By the twentieth dry cleaning, however, its shrinkage was almost the same as the others.

In the filling direction, shrinkage was progressive through the fifth dry cleaning with little change in the next five dry cleanings, but some additional shrinkage in the last ten. Here again the yellow fabric displayed its erratic behavior.

In the dry cleaning procedure the greige goods shrank 2, 1, and 2½ per cent less warpwise after five, ten, and twenty cleanings than the treated fabrics, but closely paralleled them in filling shrinkage.

This unpredictable behavior of the fabrics could have been due to high humidity which is characteristic in Michigan. Less shrinkage occurs when rayons are dried rapidly and its is quite possible that the relative humidity was lower on the day of the third laundering. The launderings were done in the spring, a time of the year when there is a great deal of rain in Michigan.

WEIGHT PER SQUARE YARD

The weight per square yard for every fabric in Group I progressively increased with repetitive launderings and dry cleanings (See Table XI in the appendix). The only exception was the yellow fabric. Its shrinkage in both warp and filling was less after the tenth than the fifth dry cleaning. Therefore, weight increase was less at this interval than in the preceding one. Although the forest green (number 4) fabric displayed shrinkage equivalent to the other three fabrics in this group in laundering and dry cleaning, it showed less increase in weight than any of the other fabrics either laundered or dry cleaned. Number one, the pink fabric, showed an opposite performance. Its shrinkage was comparable but its increase in weight was approximately 2 per cent higher than the other three. A greater increase in weight occurred for each fabric in successive dry cleanings than in launderings. From these results greater shrinkage in dry cleaning than in laundering would be expected, but at the fifth and the tenth intervals the laundered materials had shrunk more than the dry cleaned. The greater increase in weight per square yard in dry cleaning at these specified intervals may partially be due to less loss of resin. After the twentieth dry cleaning, the combined warp and filling shrinkage was greater than at the twentieth laundering. This would account for the increase in weight per square yard after the twenty dry cleanings as compared to the twenty launderings.

The greige material's increase in weight paralleled its shrinkage. During launderings the warp sizing of the greige goods was washed out and a higher percentage of shrinkage was noted than in the treated fabrics. This resulted in more weight increase in the greige.

Because the dry cleaning fluid only partially removed the warp sizing, the greige shrank less than the dyed fabrics. Therefore, weight increase was less than that of the dry cleaned treated fabrics.

THICKNESS

Each of the fabrics thickened after continued launderings and dry cleanings except for fabric IA_2 following the fifth laundering. It was thinner by only 2.5 per cent. (See Table XII in the appendix)

After five launderings, the pink (number 1) which was the thinnest of the original fabrics increased 9 per cent, the yellow lost $2\frac{1}{2}$ per cent while the brown and green increased 4 and $5\frac{1}{2}$ per cent respectively. After the tenth laundering, the pink (number 1) had increased 18 per cent, the yellow and brown less than half as much or 8 per cent, but the green was unchanged. No change occurred in the pink between the tenth and twentieth interval. However, the yellow, brown and green at the end of the study were approximately 13 per cent thicker than their control fabrics. The increase in thickness in this group of fabrics did not parallel their dimensional change through the first ten launderings. During the last ten launderings, their increased thickness may be accounted for by greater shrinkage. The higher per cent of increase in thickness of the pink fabric at each testing interval when compared to the other three, indicates that it may have retained more of its resin finish.

The greige fabric progressively increased in thickness throughout laundering but at the termination of this study its per cent increase was less than that at the tenth interval. While increased shrinkage occurred between the tenth and twentieth intervals, the sizing on the warp yarns washed out and undoubtedly caused the major reduction in thickness.

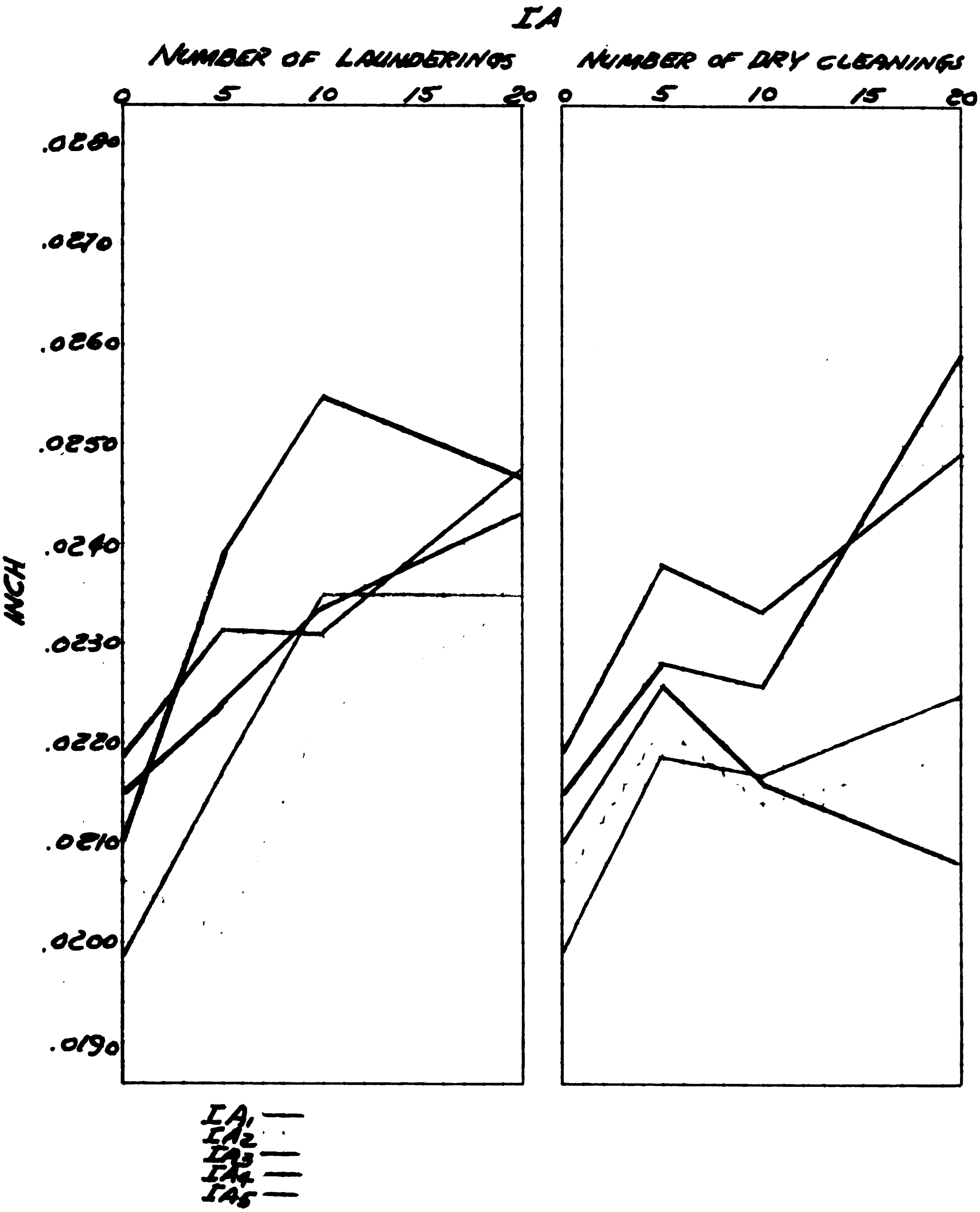
The graph on the following page clearly indicates the behavior of the Group I fabrics in dry cleanings. Thickness increased through the first five, decreased from the fifth through the tenth, but again increased from the tenth through the twentieth dry cleaning. Since shrinkage occurred in these fabrics through the first five, with only a slight increase from the fifth through the tenth and a more pronounced increase from the tenth through the twentieth dry cleaning, it may be that more resin was removed by the dry cleaning fluid between the fifth and tenth dry cleanings which would account for the decrease in thickness. Thickness of the greige material increased through the first five, but decreased in the subsequent fifteen dry cleanings. Since shrinkage of the greige was consistently more as dry cleanings progressed, it would indicate that the dry cleaning fluid removed the warp sizing after the first five intervals.

YARN COUNT

Shrinkage in this group of fabrics increased yarn counts proportionately. Negligible shrinkage and slight stretchage occurred in the filling during laundering. (See Table X in the appendix). As a result, change in warp yarns per inch was insignificant--either $\pm$ one or two yarns per inch or no change at all (See Table XIII in the appendix). Filling yarn count, on the other hand, greatly increased due to the high per cent of warp shrinkage in laundering. After

PLATE II

THICKNESS



five launderings there was an increase of 4 to 6 yarns per inch or increase of 7 to 11 per cent. After twenty launderings, the filling of three fabrics had an increase of 5 yarns per inch and the fourth 7 yarns or a 13 per cent increase.

Since filling shrinkage in the greige was 2 to 3 per cent it showed an increase of 4 in the warp yarn count. Excessive warp shrinkage in laundering increased its filling yarn count by ten after the twentieth laundering.

Filling shrinkage during dry cleaning was under 2 per cent for fabrics two, three and four at the fifth and tenth dry cleanings and increased the corresponding warp yarn count by approximately one yarn per inch. The number of filling yarns per inch increased proportionately to warp shrinkage--a maximum of four yarns after five, three after ten and six after twenty dry cleanings.

There was no appreciable change in warp yarn count in the treated fabrics during laundering but a slight increase in dry cleaning. Filling yarn count noticeably increased during both cleaning treatments, with increase earlier in the laundering procedure than in dry cleaning. The terminal yarn counts in the filling were slightly less after dry cleanings than after launderings.

DRAPABILITY

At each laundering and dry cleaning interval, the drapability of these fabrics increased. (See Table XV in the appendix). After the first five cleanings, drapability values ranged from 33 to 37, with an 18 to 25 per cent increase over their initial values. At the next interval, the four fabrics showed more marked individual differences and now had less drapability than at the preceding interval, but still had better performance over the original specimens by 4, 16, 17 and 11 per cent for materials one, two, three and four respectively. At the conclusion of the study, there was a wider range in their drapability; namely 32 to 41. Improvement in their draping qualities over their initial values was 29, 25, 19 and 9 per cent for the four fabrics in sequence, one through four.

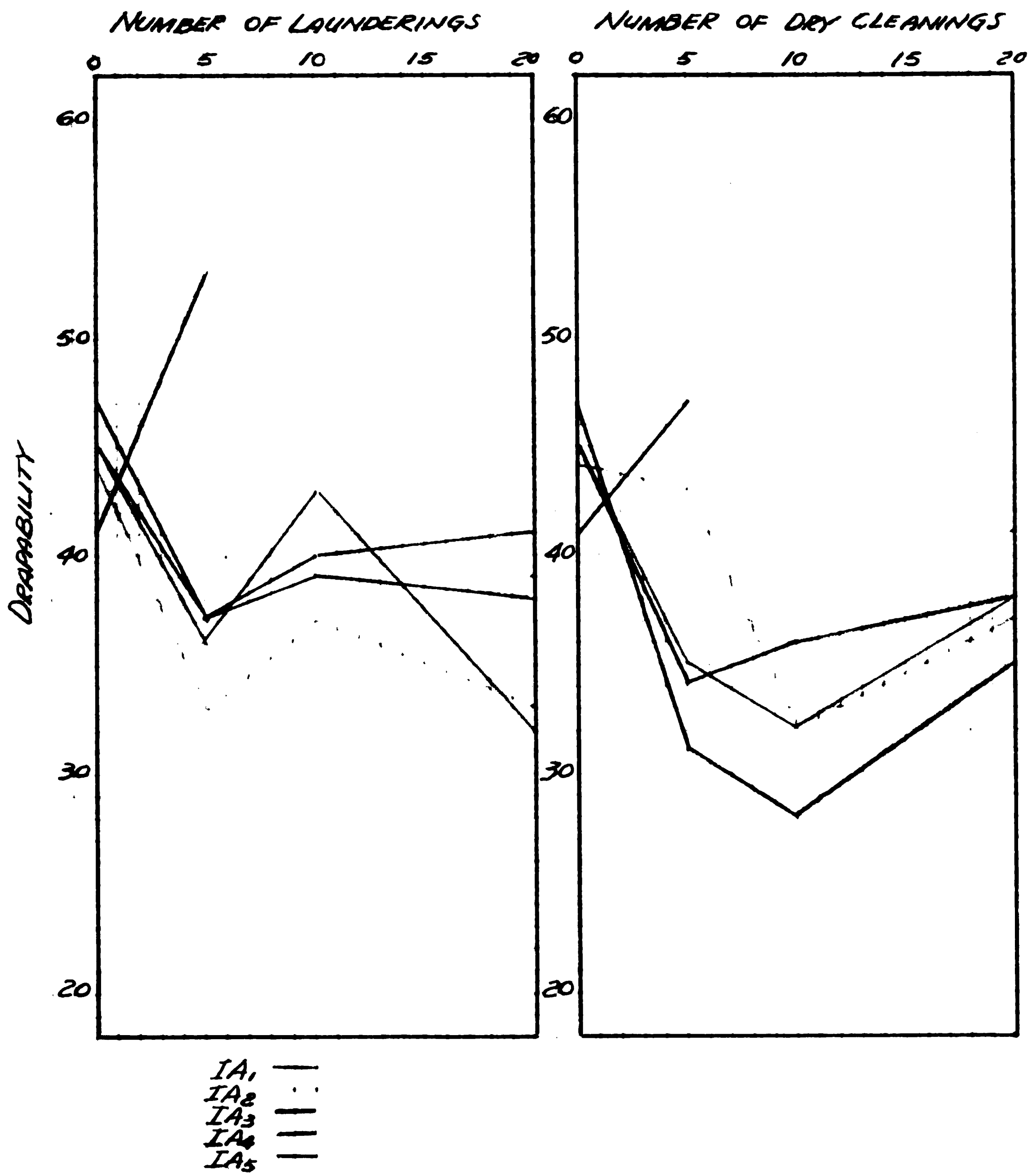
The greige gabardine after five launderings did not drape as well as its control. In fact, it maintained only 70 per cent of its drapability and was much lower in draping performance than the treated materials. The diffusion of the sizing probably accounts for this change. At the termination of laundering, its drapability was equivalent to the treated fabrics and had improved in draping over its initial performance by 5 per cent.

After five and ten dry cleanings, the drapability of each fabric increased more than after comparable launderings. (See Plate III, page 82). Fabric two was the exception. Following the fifth dry cleaning it was much lower than at the corresponding laundering, only 2 per cent compared to 25 per cent. The brown gabardine showed greatest improvement in drapability. The other three which performed dissimilarly at the interval cleanings were equivalent in drapability at the terminal dry cleaning but 10 per cent lower

PLATE III

DRAPABILITY

IA



in performance than the brown material.

At the fifth dry cleaning the greige did not drape as well as it had initially nor did it drape as well as the treated fabrics dry cleaned the same number of times. Its drapability increased until its test results of the twentieth interval indicated it to perform as well as its control.

WRINKLE RECOVERY

After five launderings and five dry cleanings, significant improvement over original recovery from creasing was seen in both the warp and filling of each fabric in this group. (See Plates IV and V, pages 84 and 85). Continued increases were seen in subsequent launderings and dry cleanings but were less pronounced.

The warp wrinkle recovery of the pink and brown materials increased through the first ten launderings. After the next ten there was a slight loss in improvement. On the other hand, the warp of the yellow and green materials consistently improved in recovery from wrinkling with successive launderings. After five launderings the per cent of increase in wrinkle recovery for the four fabrics ranged from 18 to 34 per cent. (See Table XVI in the appendix). After the fabrics had been subjected to five more launderings, their recovery again increased. Their degree of return after creasing was 130 to 137; a plus 19 to 44 per cent change over their initial wrinkle recovery values. At the end of the study warp recovery from creasing was 27, 23, 35, and 43 degrees higher than the initial values for fabrics one through four.

PLATE IV

WRINKLE RECOVERY

NUMBER OF LAUNDERINGS

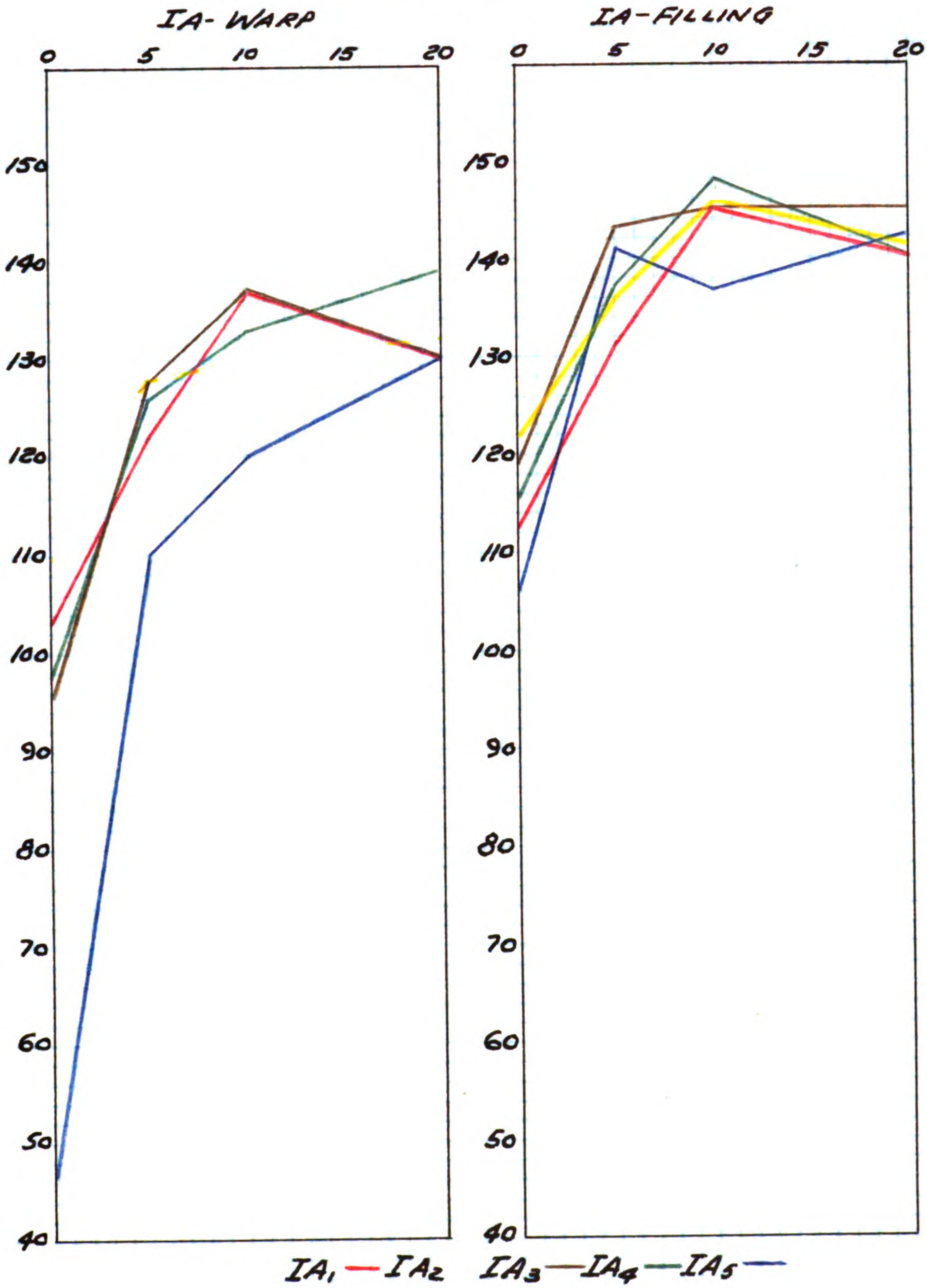
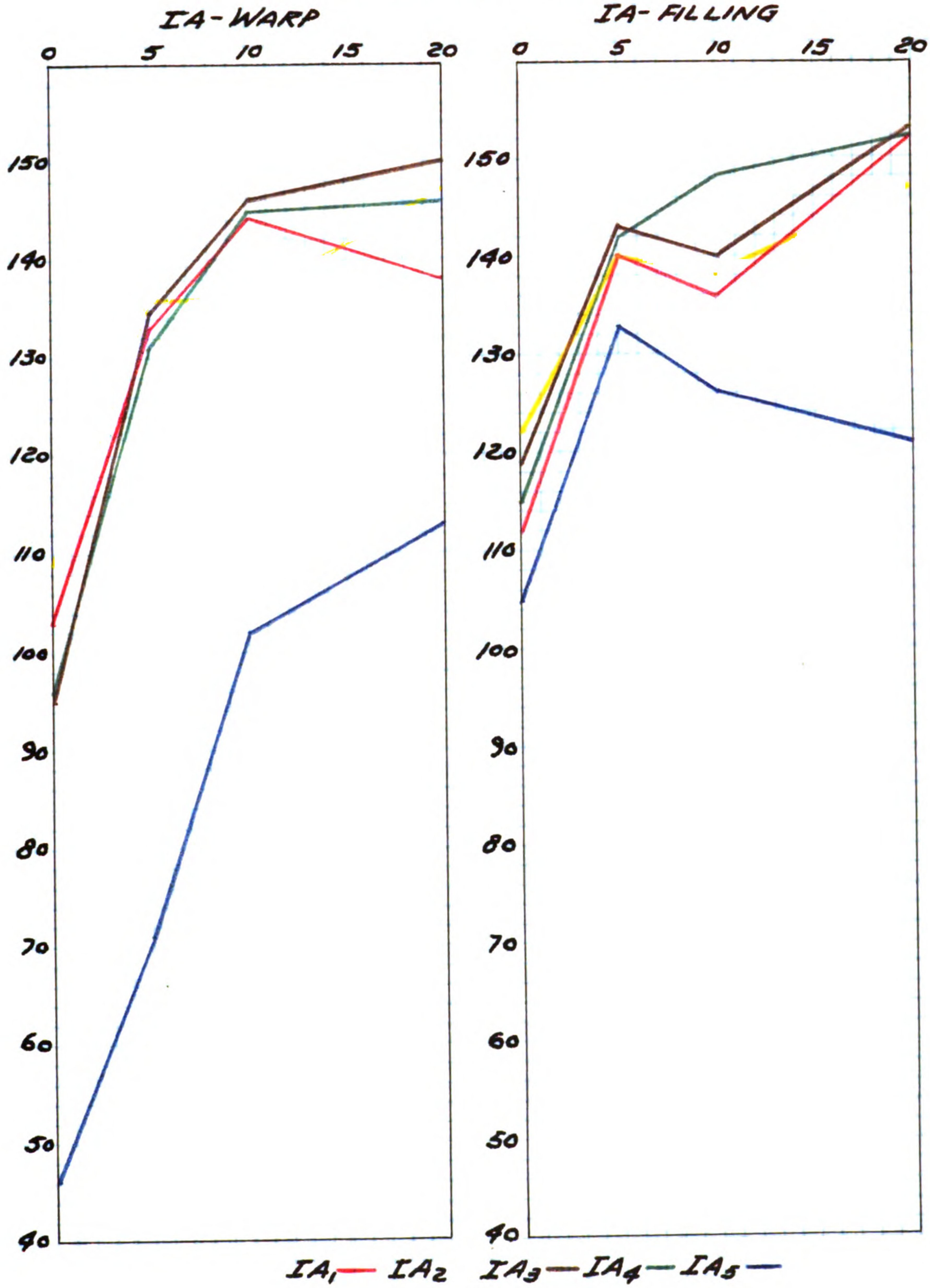


PLATE V

WRINKLE RECOVERY

NUMBER OF DRY CLEANINGS



The warp greige which had low initial recovery increased 139, 160 and 182 per cent after five, ten and twenty launderings. Its recovery was 16 degrees lower than the average of the treated goods after five launderings; 14 degrees lower at ten, and only 3 degrees lower after the twentieth laundering.

The higher initial wrinkle recovery of the filling remained throughout laundering. The pink, yellow and green showed continuous improvement in the first ten launderings, with a slight loss after the second ten. After five launderings, the degree of recovery ranged from 131 to 143, an increase of 11½ to 20 per cent over the initial values. After ten launderings, the range of 145 to 148 degrees (19 to 29 per cent increase) is significant as was the 15 to 25 per cent increase at the termination of the study.

Since the filling of the greige was superior to the warp in initial wrinkle recovery, it did not show as much improvement during laundering as the warp. Its wrinkle recovery value (141°) was comparable to the treated fabrics after five launderings; was 9 degrees lower than the average of the treated materials after ten, but after twenty was again equivalent to the average of the treated materials. Its increase was 34, 30½ and 35 per cent at the specified testing intervals.

The warp wrinkle recovery values in this group of fabrics after dry cleanings were higher than their corresponding values after a comparable number of launderings. Fabrics two, three and four improved with successive dry cleanings, while fabric one showed less recovery in the last ten dry cleanings. After five, ten, and twenty dry cleanings the average for the group was approximately 8, 9 and 12 degrees higher than after equivalent launderings. The warp of the brown consistently showed greater change in dry cleaning than the other three fabrics.

The warp greige during dry cleaning recovered more slowly and to a lesser degree than in laundering. The wrinkle recovery value of the greige compared with the treated fabrics was 63, 41, and 32 degrees lower after five, ten and twenty dry cleanings respectively.

The dry cleaned materials (fillingwise) after the fifth treatment had a higher wrinkle recovery average by 4 degrees than after five launderings. This was due to the better recovery of fabrics one, two and four. At the termination of the study the filling of the four dry cleaned fabrics averaged 9 degrees higher in recovery than the laundered materials. Throughout the dry cleanings, no one fabric showed consistently greater improvement in the filling direction than the other three. However, fabric two showed less improvement in wrinkle recovery than the other three fabrics at each dry cleaning interval.

The filling recovery of the greige was lower than that of the treated fabrics throughout the twenty dry cleanings. It was 8, 11 and 21 degrees lower after five, ten and twenty dry cleanings than after a comparable number of launderings.

COMPRESSIBILITY

Plate VI on the following page shows the four treated fabrics to have more resistance to compression after five launderings than their controls. This per cent change in compressibility ranged from 1 to 21 (See Table XVIII in the appendix). After the tenth laundering the fabrics went to the other extreme and had a higher rate of compression than their originals. However, in the last ten launderings the trend was again reversed. At the termination of the study the pink and brown fabrics were 3 and 17 per cent lower in compressibility than originally, the yellow was 19 per cent higher, while the green material remained approximately the same in compressibility as its original.

The greige goods steadily increased in compressibility through successive launderings.

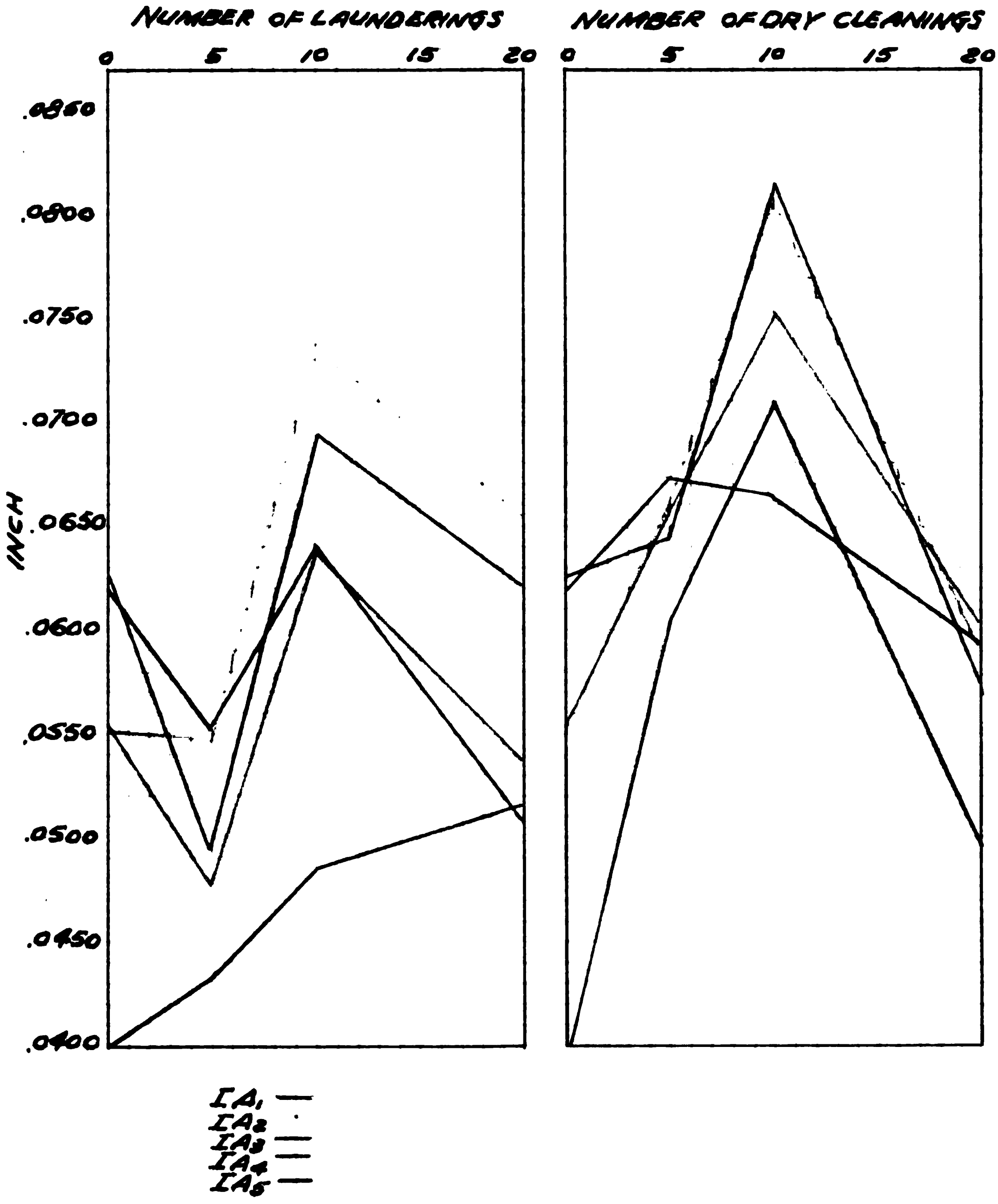
After the fifth dry cleaning each of the fabrics varied little from the average for the group which was an increase over the compressibility of the control fabrics. At the next testing interval fabrics one, two and four had a much higher ratio of compressibility, while the brown material showed slightly less. The compressibility of the four fabrics was similar after twenty dry cleanings. The pink and yellow compressed more rapidly and the brown and green fabrics more slowly than the corresponding original specimens.

The greige followed the general trend in compressibility change but was slower in its rate of compression than the treated fabrics at each of the testing intervals.

PLATE VI

COMPRESSIBILITY

IA



COMPRESSIONAL RESILIENCE

The compressional resilience of the fabrics in Group I during launderings and dry cleanings was inconsistent. (See Plate VII, page 91). Averaging their per cent of change at a specific interval as compared to the original materials gave a misleading computation, for it was not at all typical of the per cent of change for each fabric in the group.

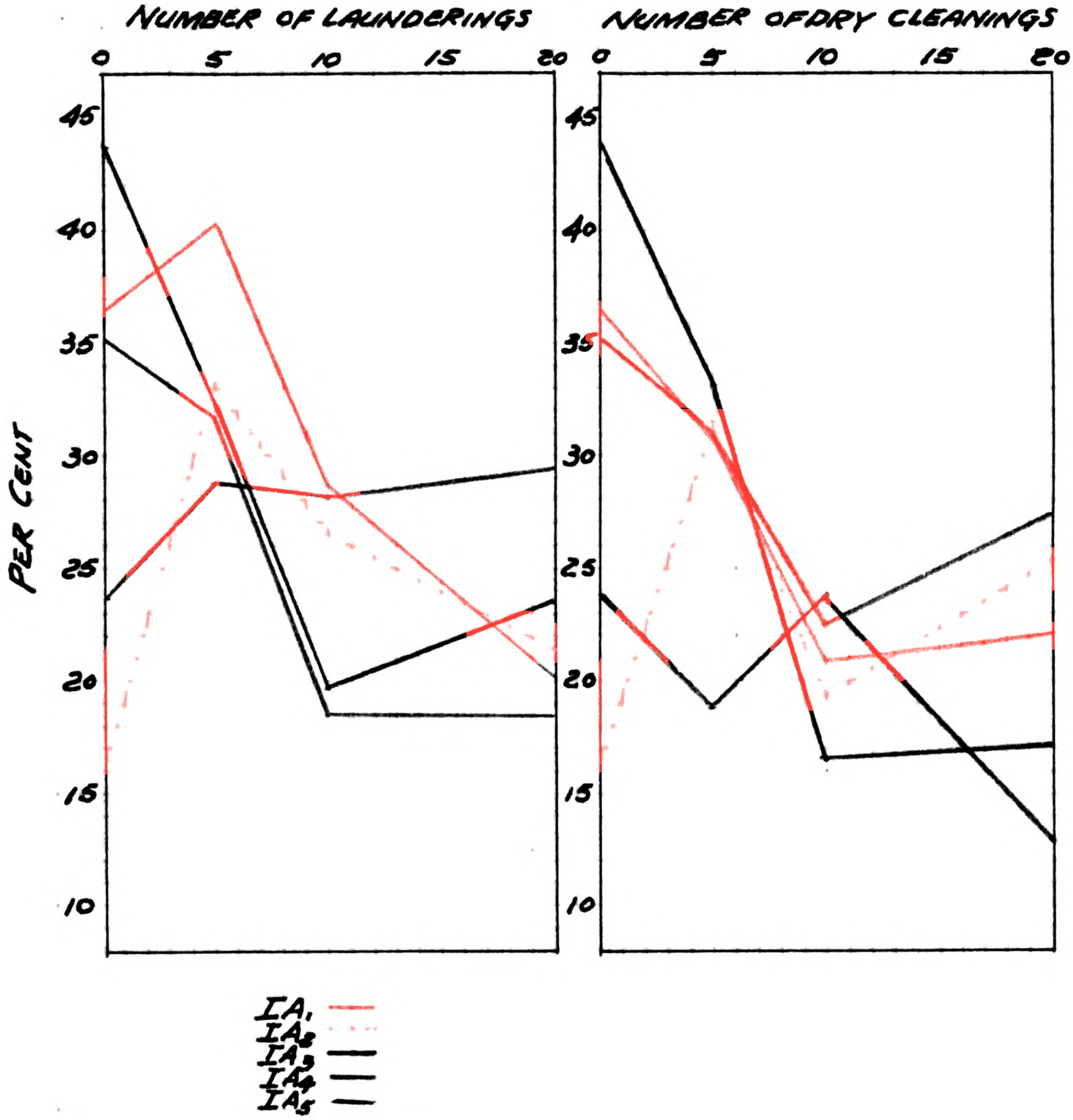
Fabric one improved in compressional resilience by 10 per cent after the fifth laundering, in the subsequent five launderings its resilience had decreased 21 per cent and in the last ten was only 55 per cent of original resilience. (See Table XIX in the appendix). Fabric two had almost 100 per cent improvement in its compressional resilience after five launderings, but this improvement decreased to 60 per cent at the tenth and was only 30 per cent better than the initial resilience at the termination of the study. The brown (Fabric three) when compared to its control progressively decreased in compressional resilience during the first ten launderings. The green (fabric four) likewise decreased but not as rapidly as the brown which at the fifth laundering was 26 per cent less resilient while the former had only 9 per cent less resilience. At the tenth and twentieth laundering intervals, they were more comparable than at the preceding interval.

The original materials had a range of 16 to 44 per cent compressional resilience, but after five launderings the differences were less marked (32 to 40); after ten launderings

PLATE VII

COMPRESSIONAL RESILIENCE

IA



and in the next ten the four fabrics ranged between 18 and 29 per cent. Each of the fabrics decreased in its compressional resilience between the fifth and tenth launderings. Between the tenth and twentieth laundry intervals, both the pink and the yellow decreased, whereas the brown increased slightly and the green showed no change in compressional resilience.

The greige material improved in resilience after laundering. At the fifth it was approximately 3 per cent less than the green, which had the lowest resilience of the treated gabardines. However, after ten launderings, it was within 1 per cent of the pink which had the highest resilience at this interval. After twenty launderings its resilience was superior to any of the treated fabrics.

From Plate VII it can be seen that the compressional resilience for the dyed fabrics after five dry cleanings was similar. From the fifth through tenth a noticeable drop was observed. After the twentieth dry cleaning the green and yellow fabric showed significant improvement while the pink and brown improved only slightly.

The compressional resilience of the greige fabric decreased with five dry cleanings but showed improved resilience after ten dry cleanings. At this time it had more ability to return to its initial height after compression than the treated materials. However, by the twentieth dry cleaning, it had lost resilience and had an extremely low value of only 13 per cent; when compared to the treated fabrics it was approximately 10 per cent less than their average.

BREAKING STRENGTH IN POUNDS

The greatest variance in tensile strength for this group of gabardines was in their initial values. After a specified number of either launderings or dry cleanings, there was less variation within the group. In general, the yellow fabric was consistently lower than the other three fabrics in both (wet and dry) determinations for warp and filling in either cleaning treatment (See Plates VIII and IX, pages 94 and 95).

At the fifth laundering interval, the (dry) warp of the pink had less strength than originally; the yellow and brown had gained slightly, while the green remained approximately the same. The average for the group was 64.2 pounds and was quite typical of each fabric (See Table XX in the appendix). Between the fifth and tenth launderings, fabric one averaged a 2 pound loss, while fabrics two and three averaged 9 and 6 pounds less respectively. On the other hand, fabric four increased 4 pounds. In the following ten treatments fabrics one and four maintained approximately the same strength as seen after ten launderings; fabrics two and three gaining 3 and 7½ pounds respectively. At the terminal laundering, the pink, brown and green fabrics varied 2 pounds in strength, while the yellow was 3 pounds less. The group average was only .7 pound less than the corresponding initial strength values.

Filling (dry) tensile strength of fabrics one, two and three increased through the first ten launderings, with

PLATE VIII

BREAKING STRENGTH

IA

NUMBER OF LAUNDERINGS

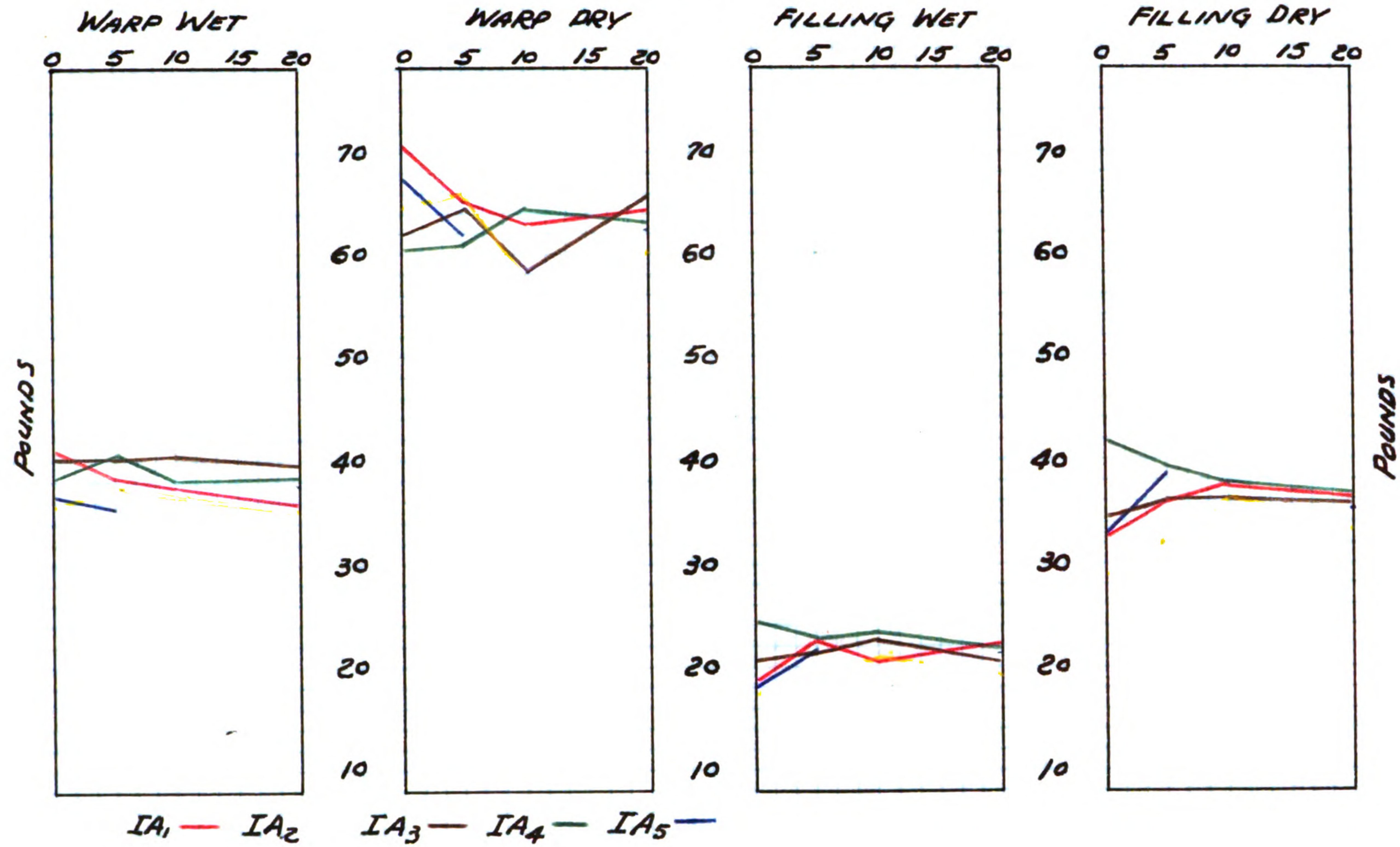
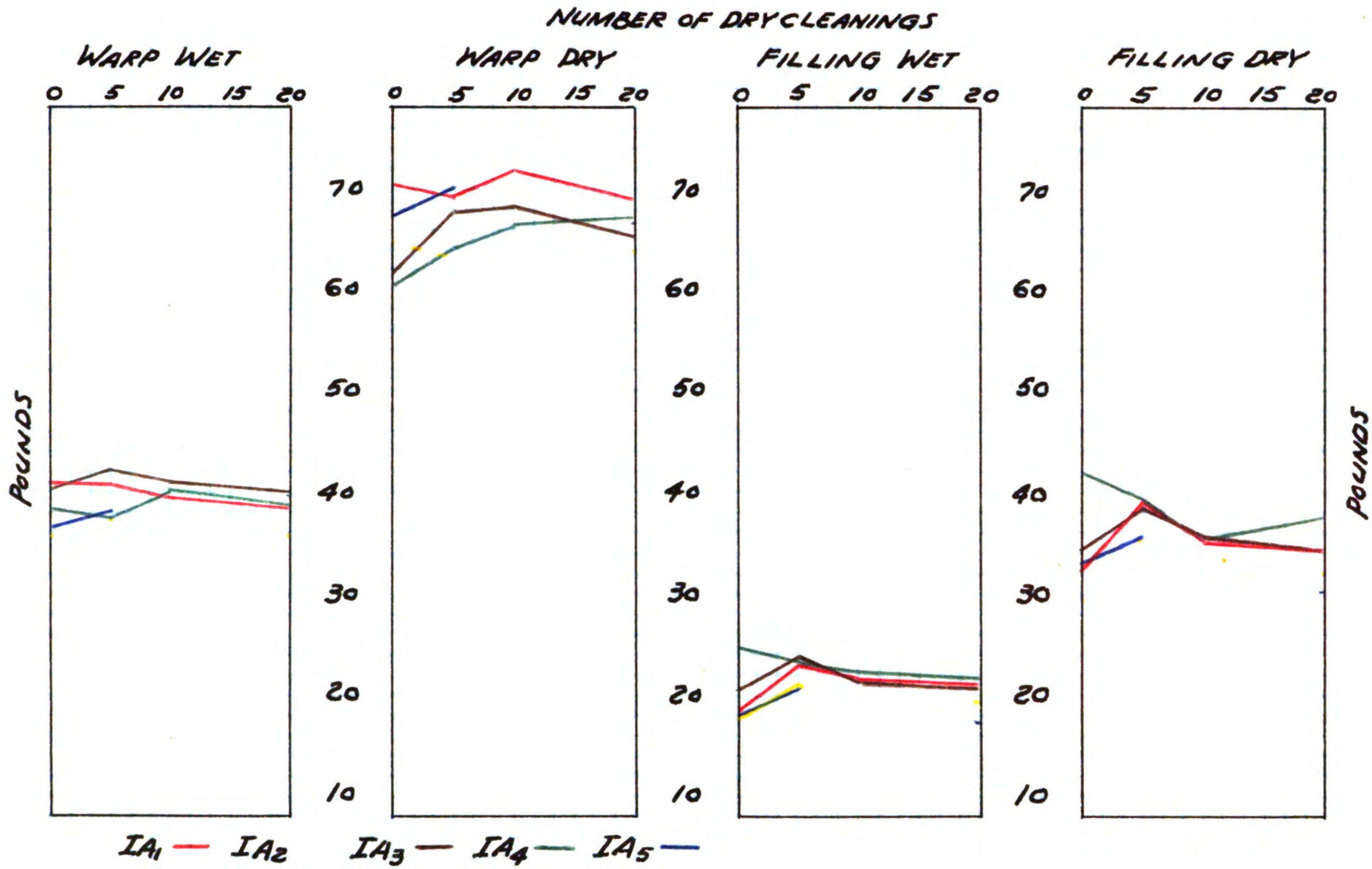


PLATE IX

BREAKING STRENGTH

IA



slight loss during the following ten. Fabric four decreased through successive launderings. At the tenth and twentieth intervals, the four fabrics had similar filling (dry) strength.

In general, these fabrics increased slightly in warp (dry) strength between the fifth and tenth dry cleanings as compared to a similar loss during corresponding launderings. The average of the group was 2 pounds higher than the average of the original materials at the end of the study with strength variation of 6 pounds compared to 10 pounds in the original fabrics.

Average filling (dry) strength of the treated fabrics increased 3 pounds during the first five dry cleanings, but was comparable to original strength at the termination of the study.

Wet tensile strength determinations for both warp and filling were more uniform than dry determinations at any specified interval. Wet strengths were approximately 60 per cent of dry strength in both warp and filling.

Both the (wet and dry) warp and filling of the greige were similar to the average strength of the treated fabrics at each testing interval.

ELONGATION

Warp wet elongation was slightly higher than dry after both laundering and dry cleaning (See Plates X and XI, pages 97 and 98).

There was a slight increase in warp (dry) elongation

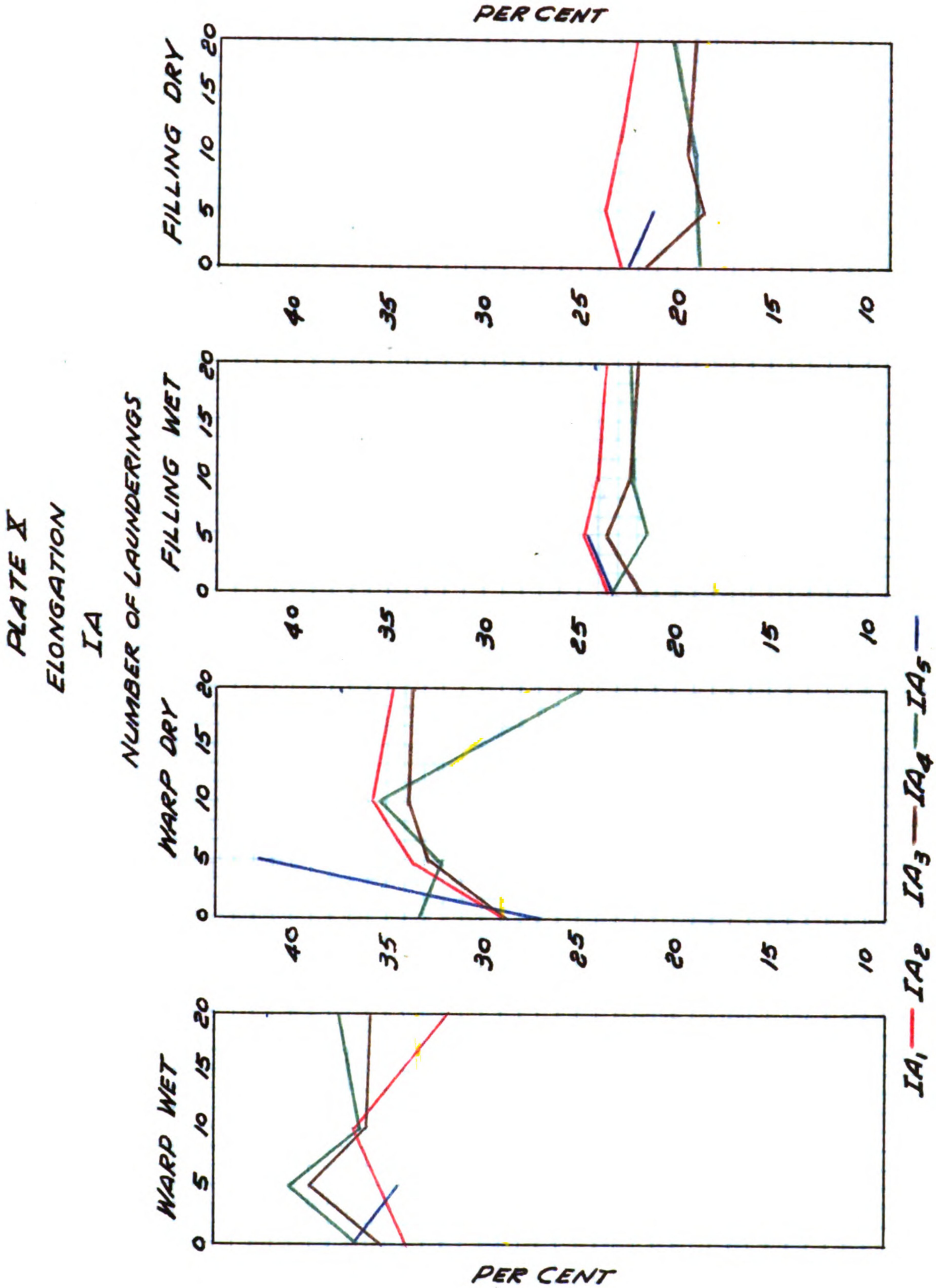
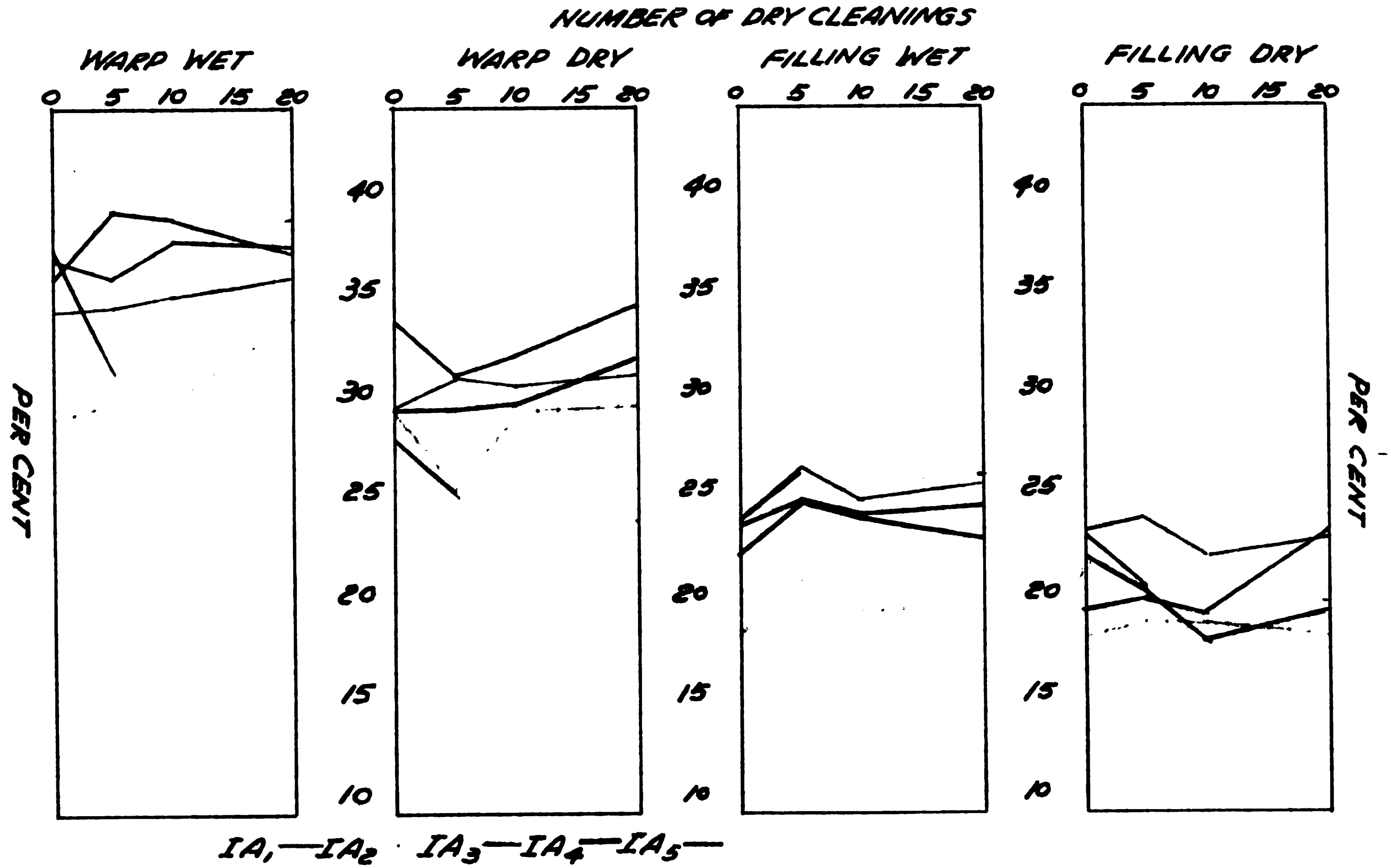


PLATE X
ELONGATION
IA
NUMBER OF LAUNDERINGS
PER CENT
FILLING DRY
FILLING WET
WARP DRY
WARP WET
PER CENT
0
5
10
15
20
40
35
30
25
20
15
10
IA₁ — IA₂ — IA₃ — IA₄ — IA₅ —

PLATE XI

ELONGATION

IA



during laundering but a slight decrease in dry cleaning. At the termination of the study the (wet and dry) averages for the four fabrics in either procedure were similar to their initial averages (See Table XXII in the appendix).

When compared to their controls both dry cleaning and laundering slightly increased warp (wet) elongation. The warp of the yellow fabric which had the lowest tensile strength elongated less before tearing than any of the other fabrics.

Wet and dry elongation in the filling after launderings was equivalent; while the wet determinations were slightly more than the dry in dry cleaning. The terminal (wet and dry) filling averages in either cleaning treatment were close to the corresponding initial averages.

The pink material had the highest elongation in the filling while the yellow fabric stretched the least and was also the weakest at each testing interval.

Dry warp determination in the greige showed more stretch than the treated fabrics in laundering, but less stretch after a corresponding number of dry cleanings. The greige warp (wet) stretched similarly to the finished materials after five of either cleaning treatment. After twenty it showed more stretchage than the four dyed materials. Filling elongation was similar to that of the finished fabrics.

ABRASION RESISTANCE

In general, the number of cycles for abrading to first sign of wear and hole increased for each fabric at each successive laundering interval (See Table XXIV in the appendix). However, from the histogram on the following page the yellow material is seen to be an exception; with 18 fewer cycles for first sign of wear at twenty launderings than after ten. In each fabric the first sign of wear or broken yarn occurred in the warp.

During laundering the green fabric showed best resistance to abrading to a hole.

The number of cycles for first sign of wear and a hole in the initial testing of the greige approximated the averages of the finished fabrics. However, after five launderings, the greige was superior in abrasion resistance when considering both first sign of wear and hole. After twenty launderings, the greige was again comparable to the finished goods.

In general, there was less variation in the abrasion resistance of the fabrics after dry cleaning than after a corresponding number of launderings. The number of cycles for first sign of wear of the pink material was less after five dry cleanings than initially, but in the last fifteen cleanings it showed improved resistance. The brown fabric recorded the greatest number of cycles for first sign of wear after five dry cleanings, showed progressive loss in the following fifteen cleanings and ranked third at the conclusion of the study.

The yellow and green fabrics had more resistance to abrasion after dry cleaning than their corresponding originals. They required less number of cycles for first sign

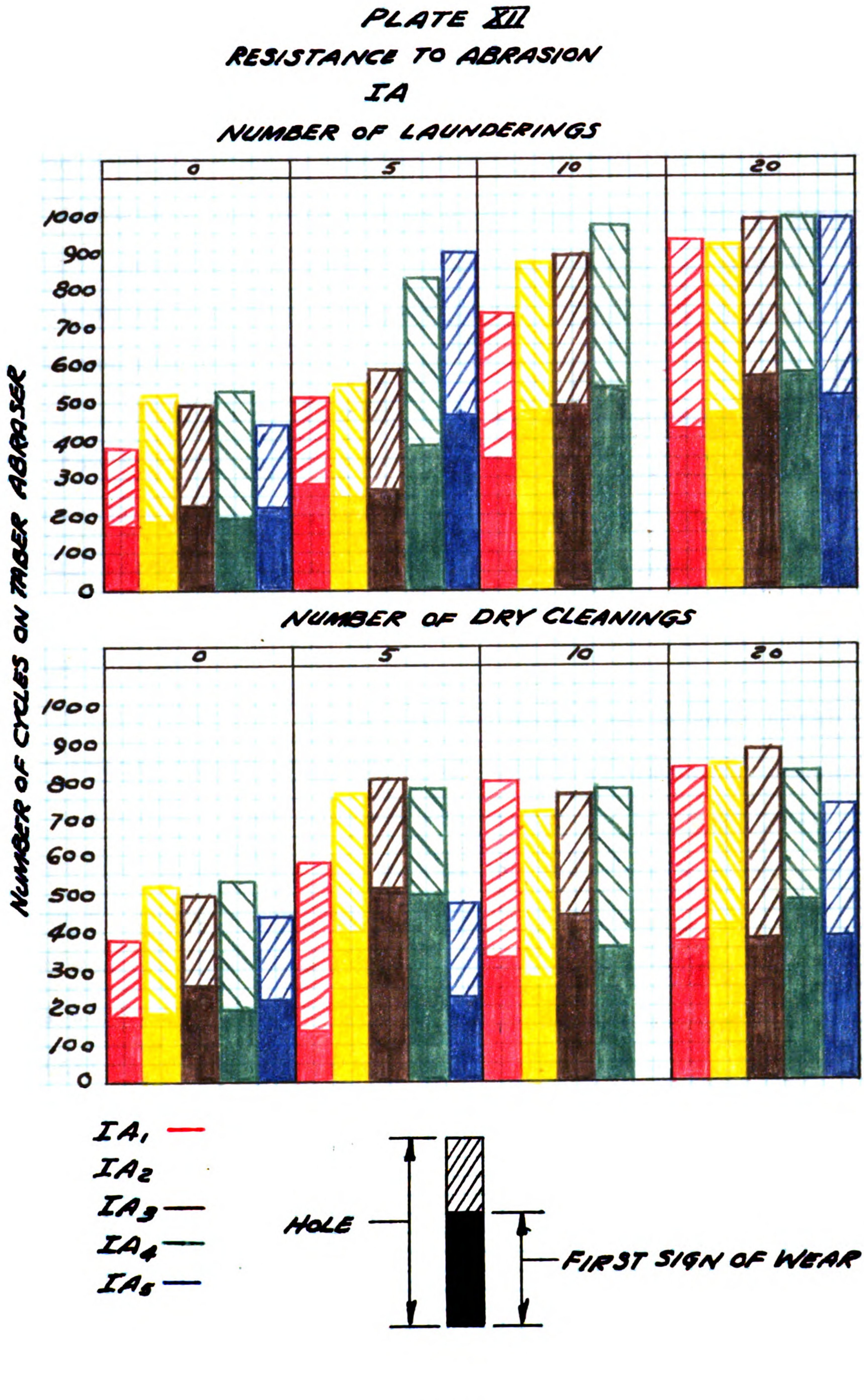


PLATE XII
RESISTANCE TO ABRASION
IA
NUMBER OF LAUNDERINGS
0
5
10
20
NUMBER OF CYCLES ON TABER ABRASER
1000
900
800
700
600
500
400
300
200
100
0
NUMBER OF DRY CLEANINGS
IA1
IA2
IA3
IA4
IA5
HOLE
FIRST SIGN OF WEAR

of wear at the tenth than after the fifth and twentieth dry cleanings.

The histogram shows the number of cycles for a hole to be approximately the same for each of the fabrics at a specified dry cleaning interval. An exception was the pink material which was lower after five dry cleanings than the other three fabrics.

At the fifth dry cleaning the greige required a few more cycles for first sign of wear and hole than its original, but was generally lower than the finished fabrics. At the terminal dry cleaning the number of cycles for first sign of wear was comparable to the finished fabrics, but lower for abrading to a hole.

The four fabrics had greater abrasion resistance after ten and twenty launderings than after a corresponding number of dry cleanings. One hundred additional cycles each were recorded for first sign of wear and hole. This was undoubtedly due to greater shrinkage during laundering.

It was of significant interest to see how badly the fabrics were worn on the Taber Abraser before a hole appeared. Plate XXXI in the appendix is typical of what occurred in the laundered fabrics while Plate XXXII indicates their appearance after testing at specified dry cleaning intervals. The warp yarns of the original specimen were practically removed by the abrasion wheels although it recorded a much lower number of cycles for a hole than the laundered or dry cleaned specimens. The number of warp yarns removed in abrading to a hole was much less after five, ten, and twenty launderings than after the corresponding dry cleanings. It can be seen from Plates XXXI and XXXII that these laundered specimens required as many or a greater number of cycles before a hole appeared but they retained more of their warp yarns during abrasion. At the fifth dry cleaning, warp yarns were worn as badly as the original was when abraded to a hole. The loss in the warp when abrading to a hole decreased with successive dry cleanings. After the twentieth dry cleaning the degree of wear was comparable to that following the twentieth laundering.

The same wear occurred in the light as well as the dark colored fabrics (See Plate XXXIII in the appendix). The original and the specimen dry cleaned ten times show more uniformity in wear than the specimen abraded after ten launderings. The hole at the top of the laundered specimen was disregarded in comparing fabric wear for it was caused by a crease in the material due to uneven clamping of the fabric on the turntable. Both the laundered and dry cleaned samples were abraded over 700 cycles, thus placing these two specimens on a comparable basis.

The greige (Plate XXXIV in the appendix) also shows the high per cent of wear in the original and dry cleaned samples as compared to the lower amount of wear in the laundered specimen, although it had been abraded many more cycles. The laundered specimen looks more tightly woven than the other two. This is due to the high per cent of shrinkage that occurred.

COLORFASTNESS TO LIGHT

Each of the Group I fabrics was Class 0 after five, ten and twenty launderings and dry cleanings (See Table XXV in the appendix). This was a noticeable change in color after only ten hours exposure in the Fade-Ometer.

COLORFASTNESS DURING LAUNDERING AND DRY CLEANING

The first detergent solution of IA_1 turned light pink. During this same laundering there was considerable bleeding of the yellow, brown and green materials. The greige fabric immediately lost color in the washing solution and during subsequent rinsings a blue tint was still noticeable. The greige did not retain the marking ink as well as the treated fabrics, giving some of the specimens a muddy brown color during the first laundering that was not removed during the remaining treatments.

Slight bleeding was again seen during the second laundering for IA_1 and IA_2. IA_3 showed color change in the laundering solution up to the fifth treatment while the green material noticeably bled until the sixth laundering.

The test cloth sewed on each of these fabrics was appreciably discolored after one laundering but tended to lose this staining through the following nineteen.

The test cloth sewed to each of the five specimens dry cleaned showed no color change through the twenty treatments.

Group II

DIMENSIONAL STABILITY

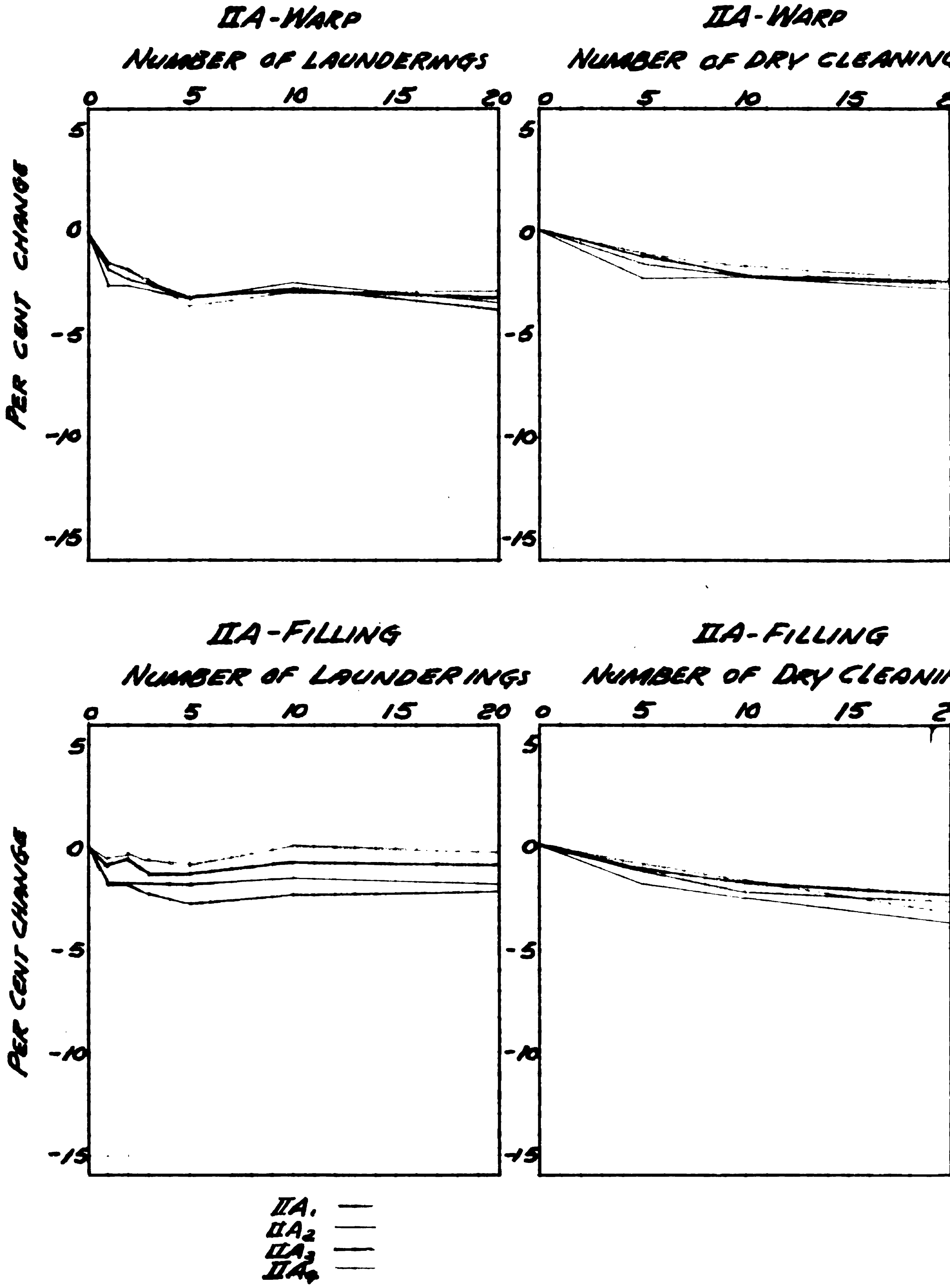
Fabric one, the brown and grey twill, had acceptable shrinkage (not over 2 per cent) in both warp and filling after one laundering (See Table X in the appendix). Fabrics three (the herringbone) and four (the check) had less than 2 per cent shrinkage in either direction through two launderings. The warp of the black and white twill (number 2) had a $2\frac{1}{2}$ per cent shrinkage after the first laundering. The graph on the following page indicates the effect of laundering and dry cleaning on dimensional change of the fabrics in Group II.

There was progressive shrinkage in the warp through the first five launderings with the four fabrics showing similarity in their per cent change. Therefore, the averages of -1.87 per cent after the first, -2.11 after the second, -2.50 after the third and -3.20 after the fifth were typical for each of the fabrics within this group. Less shrinkage occurred between the fifth and tenth launderings. Between the tenth and twentieth shrinkage continued with a final average of 3.28 per cent. Warp shrinkage in fabric two occurred earlier in the sequence of launderings than the other three fabrics. However, by the fifth laundering, the warp shrinkage in the four materials was equivalent.

Filling shrinkage for each of the four fabrics occurred during the first laundering with only a slight increase in subsequent launderings. Fabric two maintained its filling shrinkage of the first laundering through the following

PLATE XIII

DIMENSIONAL STABILITY



nineteen, with only a slight deviation at the tenth interval. The filling of the brown and grey twill (number 1) had more than 2 per cent shrinkage after the third laundering, which was retained thru the remaining seventeen. The other three fabrics of this group were within 2 per cent residual shrinkage in the filling throughout the twenty launderings.

The brown and grey twill (number 1) and the herringbone (number 3) had acceptable shrinkage through five dry cleanings, while the check (number 4) had less than 2 per cent shrinkage through ten. The black and white twill (number 2) had more than 2 per cent shrinkage after either five dry cleanings or launderings.

Warp shrinkage in dry cleaning was consistently less than in laundering.

In the filling, the per cent of shrinkage after five dry cleanings and five launderings was the same, except for the brown and grey twill (fabric 1) which had greater shrinkage at the fifth laundering interval than the corresponding dry cleaning interval. On the other hand, the average filling shrinkage, which was typical of the group was greater after ten dry cleanings than ten launderings. It was significantly more after the twentieth dry cleaning than the twentieth laundering.

WEIGHT PER SQUARE YARD

In general, the weight per square yard of the suitings progressively increased through repetitive launderings and dry cleanings (See Table XI in the appendix). A greater per cent of increase was seen after the fifth and tenth launderings than after a comparable number of dry cleanings. At the termination of the study the dry cleaned fabrics showed more change than the laundered.

After five launderings fabrics one and two increased 5 per cent or twice as much than the other two fabrics in weight. At the tenth interval the brown and grey twill (number 1) and the black and white twill (number 2) still maintained a comparable per cent increase, while fabrics three and four had increased only 1 per cent over the preceding interval. After twenty launderings the per cent change among the four fabrics was inconsistent. Fabric one had gained 7 per cent, fabrics two and three 5 per cent and fabric four only $3\frac{1}{2}$ per cent. The higher per cent weight increase for fabrics one and two when compared to the other two after the fifth and tenth launderings can be accounted for by their higher filling shrinkage. Due to shrinkage in both directions in the last ten launderings there was progressive weight increase.

In dry cleaning as in laundering fabrics one and two showed the greater weight increase.than either fabric three or four. Fabric three did not increase as much as four after the fifth and tenth dry cleaning, but after the twentieth dry cleaning had a slightly higher per cent of increase than fabric four. This had also occurred in laundering. Greater per cent weight increase in fabrics one and two as compared to fabrics three and four after the fifth and tenth dry cleanings was due to their higher per cent of shrinkage in warp and filling.

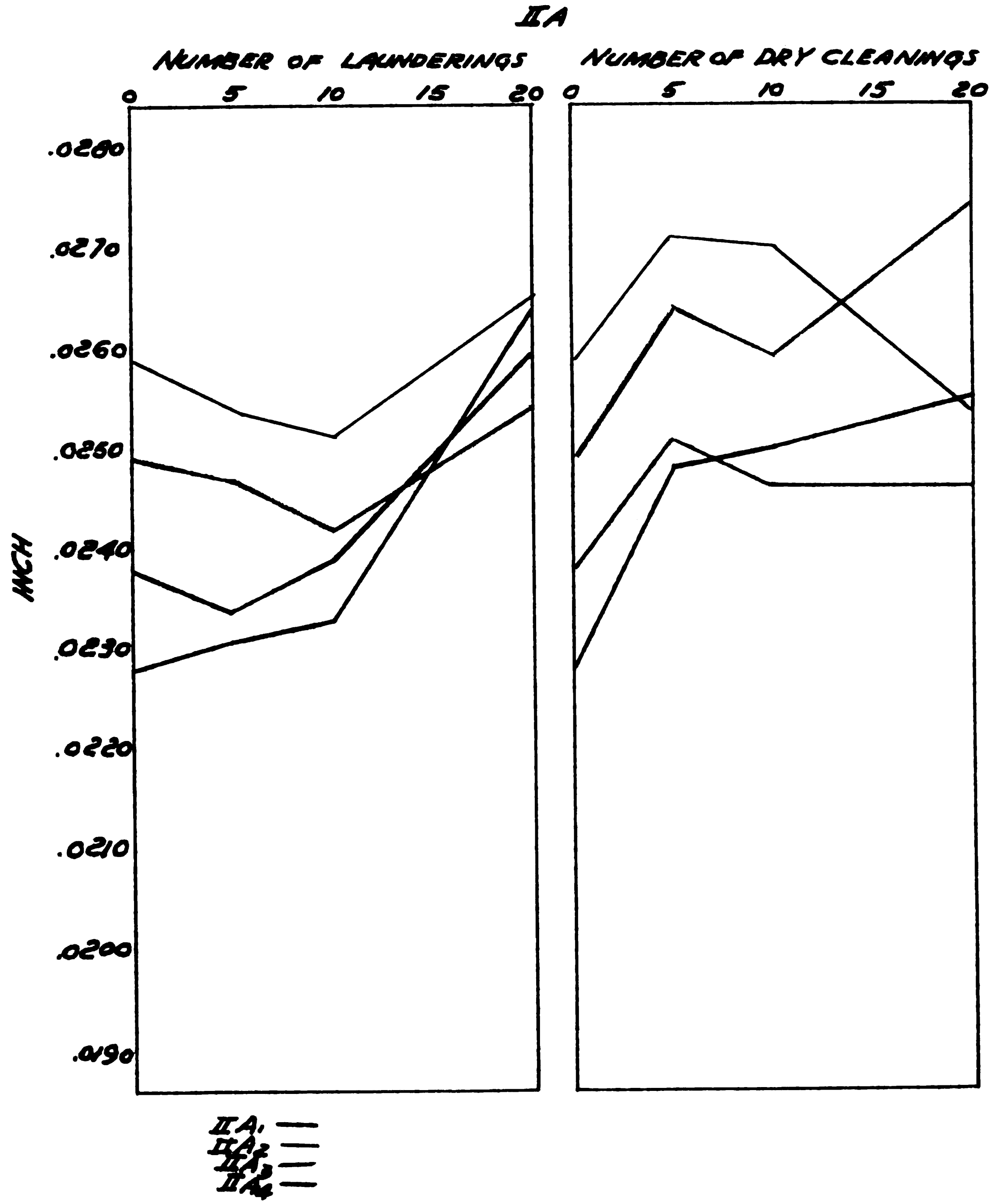
THICKNESS

Only two specific trends in thickness were seen when the suitings were laundered or dry cleaned. Thickness of the group of fabrics increased significantly in the last ten launderings and similarly in the first five dry cleanings (See Plate XIV, page 110). Between other testing intervals, unlike behavior prevailed.

The herringbone (number 3) was the only fabric to consistently increase in thickness with repetitive launderings. After the fifth laundering the thickness of fabrics four, one and two decreased about 1, $1\frac{1}{2}$ and nearly 2 per cent respectively (See Table XII in the appendix). After ten launderings, the brown and grey twill had increased less than .5 per cent, but in the last ten it increased 9 per cent over its initial thickness. Also at the tenth laundering interval, the black and white twill (number 2) and the check (number 4) were thinner than they had been after the fifth treatment. Because both increase and decrease occurred among the fabrics between the fifth and tenth intervals, the group average could not be considered typical fabric performance at those specified launderings. After the twentieth laundering, each fabric had increased in thickness ranging from 2 to 16 per cent. The average of plus 6.56 per cent was not representative of any one fabric in the group.

Only shrinkage occurred in the suitings during laundering. Therefore, decrease in thickness through the first ten

PLATE XIV
THICKNESS



launderings may have been due to loss of finish in washing. Through the twenty treatments fabric three showed comparable shrinkage to the others of the group, but its increase in thickness was significantly greater. Perhaps more of its resin was retained during laundering, but ordinarily crease resistant finishes are stabilizing and reduce dimensional change.

Each suiting increased in thickness after dry cleanings except the black and white twill (number 2) which showed loss at the twentieth dry cleaning treatment. Fabrics one, two and four were thicker after the fifth than after the tenth dry cleaning. However, after the twentieth treatment, fabric one retained the same thickness as it had at the tenth, while fabrics two and four showed loss and gain respectively. The herringbone (number 3) consistently increased in thickness with repetitive dry cleanings to a maximum of 12 per cent.

Since fabrics one, two and four were thicker after five than after ten dry cleanings, but had less shrinkage during the first series of dry cleanings, it was presumed that only a small amount of the resin was lost in the earlier dry cleaning processes. Loss appeared to be greater in repetitive dry cleanings resulting in decreased thickness and shrinkage. The herringbone had less shrinkage in dry cleaning than the other three fabrics, but a greater increase in thickness. As in laundering, it may have retained more of its resin even while shrinkage occurred.

YARN COUNT

In general, the increase in yarn count paralleled the dimensional change in the fabrics. The small amount of shrinkage which occurred in both warp and filling during both laundering and dry cleaning did not significantly increase yarn count per inch (See Table XIV in the appendix). Fabric one with approximately 2½ per cent filling shrinkage in laundering increased two yarns per inch warpwise. Filling shrinkage for the other three fabrics was under 2 per cent in laundering resulting in a negligible change in warp yarn count. Warp shrinkage for each of the four fabrics was approximately 3 per cent and final filling yarn count averaged 2 more per inch.

Warp yarn count in the dry cleaned fabrics was similarly affected by filling shrinkage. A maximum increase of three warp yarns per inch was recorded after twenty dry cleanings. Warp shrinkage increased the filling yarn count of the fabrics by only one or two per inch after five and ten cleanings. Additional warp shrinkage in two of the fabrics during the remaining ten dry cleanings increased the count by 3.

DRAPABILITY

In general, the drapability of these fabrics improved through the sequence of launderings and dry cleanings. Fabric four had the greatest improvement while fabric one showed the least.

In the first five launderings, fabrics two, three and four increased in their drapability by 12, 11 and 14 per cent respectively (See Table XV in the appendix). Fabric one, which was superior in initial drapability, decreased 4 per cent. The graph on the following page shows that the fabrics tended to be equivalent in their drapability at the fifth laundering interval. After ten treatments, fabric one's ability was the same as its control, fabrics two and three decreased slightly, while fabric four showed significant improvement. At the end of the study the drapability values of the four materials were again similar--within range of 2. At this time the fabrics showed a 6 to 19 per cent increase in their ability to drape. The averages at the specified laundering intervals cannot be considered typical of any one fabric in the group, due to such wide variation in individual performance.

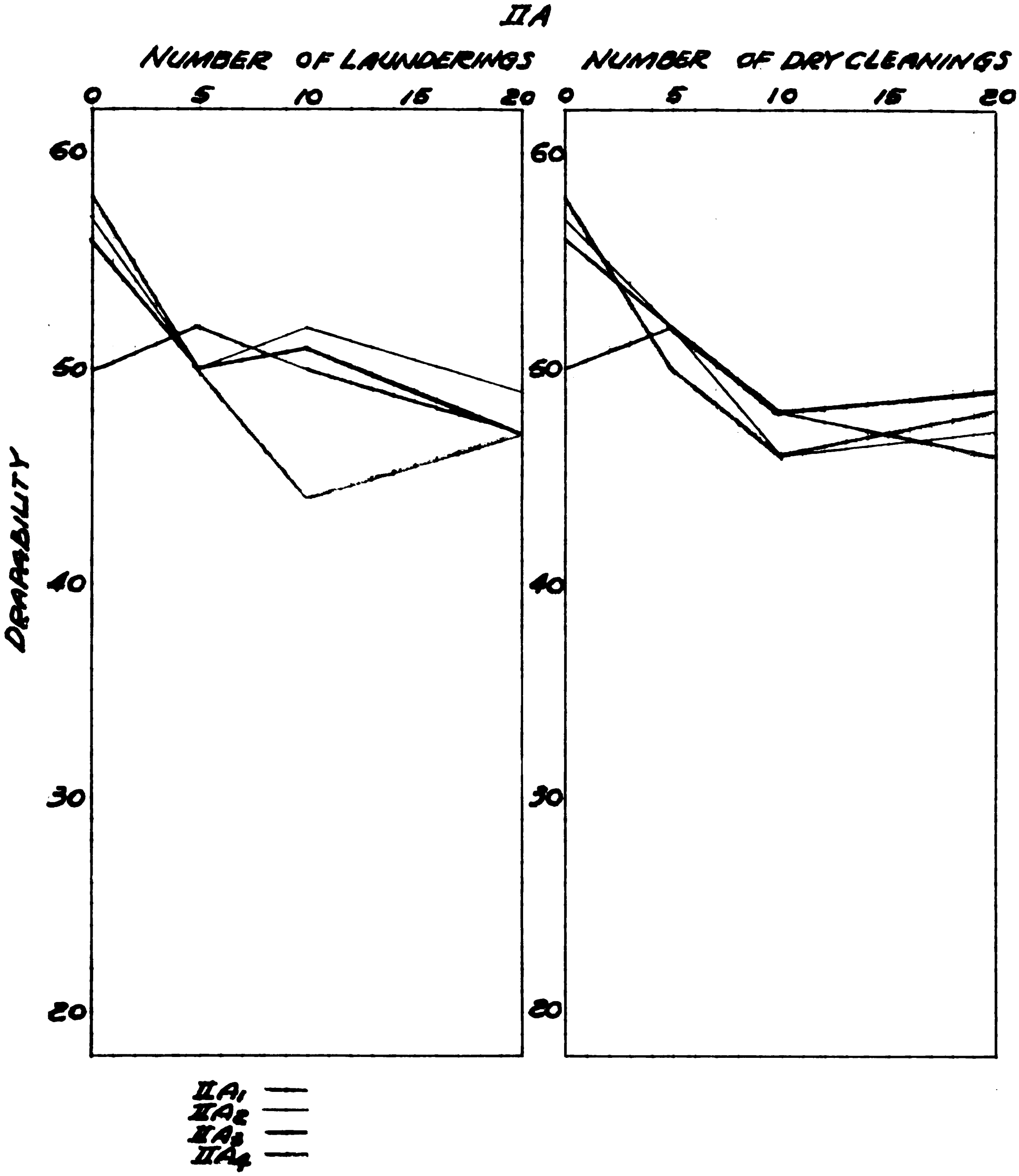
Comparable to laundering, fabrics two, three and four increased and fabric one decreased in drapability during five dry cleanings. In the next five, each fabric gained in drapability. After the final dry cleaning, fabrics one thru four were more drapable than their controls by 8, 17½, 12½ and 17 per cent. Their drapability values were with 3, showing that similarity in performance among the fabrics resulted after twenty dry cleanings.

WRINKLE RECOVERY

Each fabric in this group recovered from wrinkling to approximately the same degree as its original irrespective of how many times it had been laundered or dry cleaned. (See

PLATE XV

DRAPABILITY



Plates XVI and XVII, pages 116 and 117).

At the fifth laundering, the average warp recovery for the group exceeded that of the control fabrics by 10 degrees (See Table XVII in the appendix). Warp wrinkle recovery varied 8 degrees for the original materials, but at this interval there was a variation of 13 degrees. Also, at this time, the brown and grey twill recovered as many degrees as its original, the black and white twill had increased almost 5 per cent while the herringbone and check were higher than their originals by 11½ and 12 per cent respectively. At the tenth laundry interval the warp of the four fabrics were similar in wrinkle recovery. They now had recovery values ranging from 150 to 154 degrees, an increase of 3 to 10 per cent over their initial values. At the terminal laundering fabrics one, two and four showed continued improvement over the preceding interval, while the herringbone had slightly lower recovery. None of the fabrics was consistently lower or higher in its per cent change in wrinkle recovery. Except for the brown and grey twill which had the same warp wrinkle recovery after the fifth laundering as its control, each of the four fabrics showed improvement in wrinkle recovery at the specified testing intervals.

Wrinkle recovery in the filling of the four suitings after specified launderings showed only slight variance from their controls. The greatest variance was in the herringbone which showed consistently more improvement throughout the cleaning treatments. While it had lower wrinkle

PLATE XVI

WRINKLE RECOVERY

NUMBER OF LAUNDERINGS

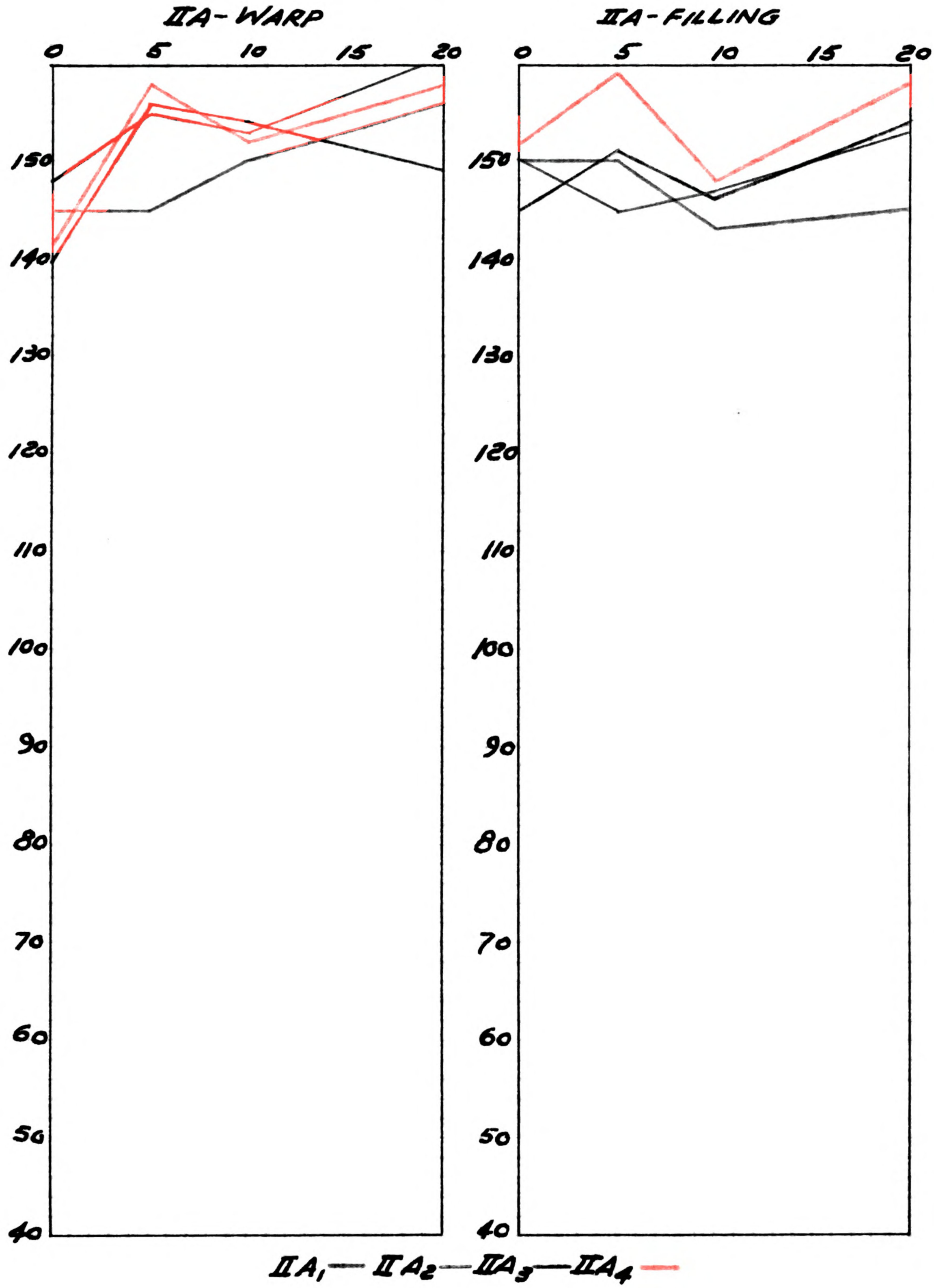
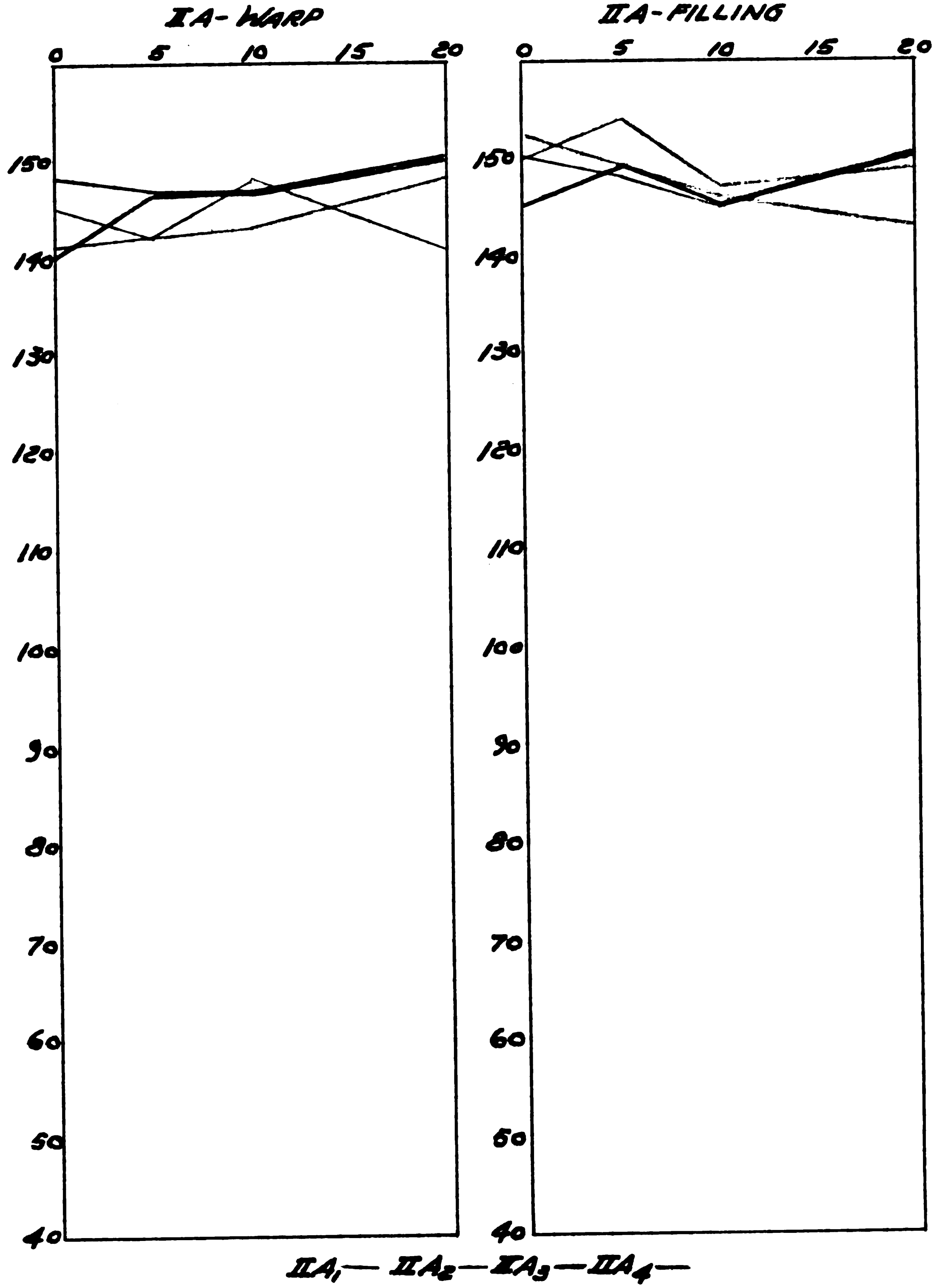


PLATE XVII

WRINKLE RECOVERY

NUMBER OF DRY CLEANINGS



recovery than the others initially, it was equivalent to the remaining three fabrics thereafter. Each fabric showed some improvement in filling recovery from creasing between the tenth and twentieth laundering. Warp and filling recovery was similar at each testing interval.

During dry cleaning, the warp of the herringbone showed the greatest per cent change at each testing interval. The averages of the four fabrics in their recovery from creasing at each period of test were slightly lower than those at the corresponding laundering intervals, and showed less per cent change from the average of the control fabrics. The warps of the brown and grey twill and the black and white twill showed both increase and decrease in wrinkle recovery after specified dry cleanings while the herringbone and check showed consistent increase in recovery.

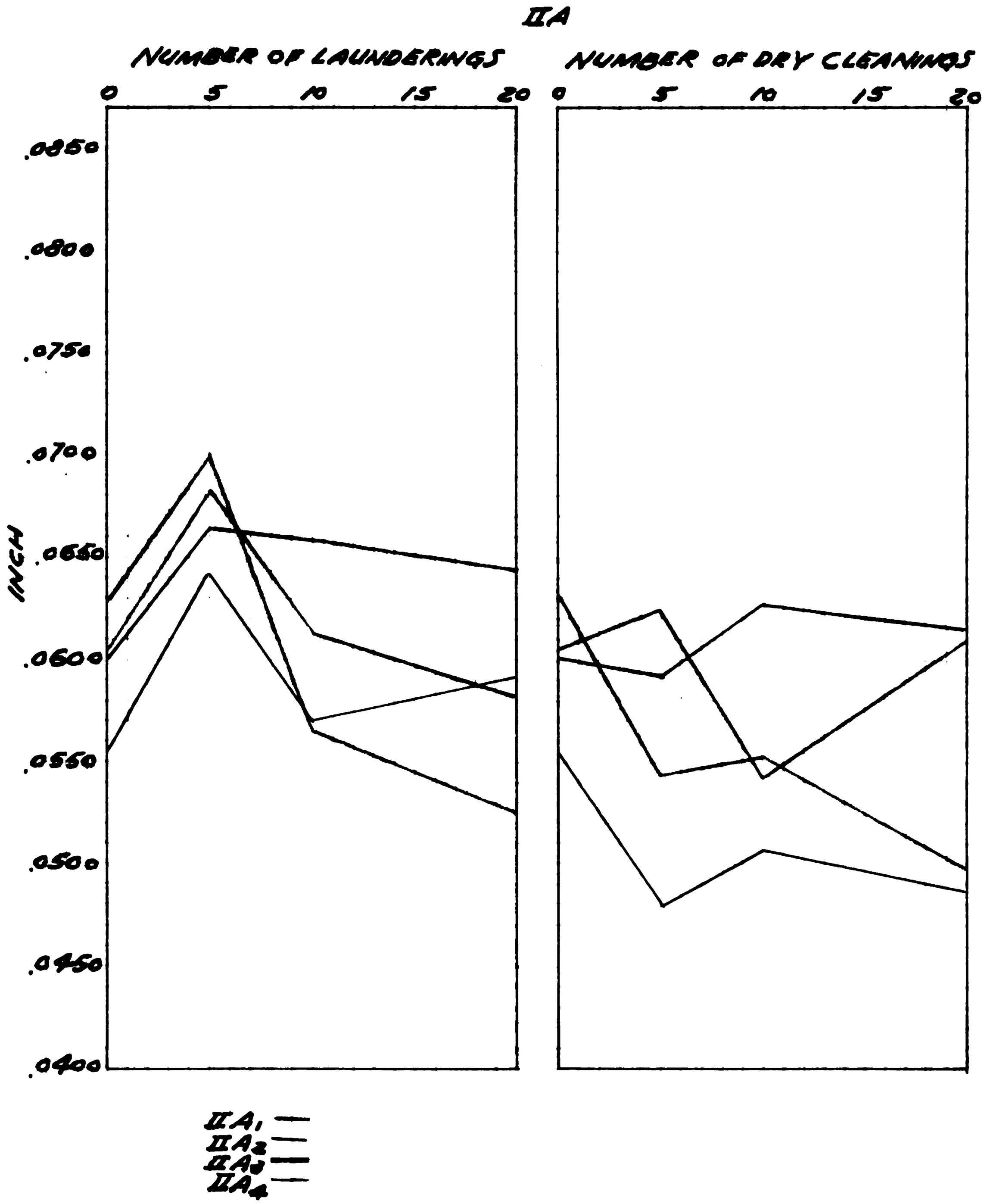
After dry cleanings recovery fillingwise for the four fabrics was comparable to that after similar launderings, for they also showed only slight change from their originals. The only significant difference in the two cleaning treatments was that the dry cleaned fabrics improved slightly less than those which were laundered.

COMPRESSIBILITY

Each of the suitings compressed more rapidly after five launderings than its original. The graph on the following page indicates their performance. From the fifth through the tenth laundering each was more resistant to compression, with the herringbone showing the least amount of change.

PLATE XVIII

COMPRESSIBILITY



Following the tenth laundering, the compressibility of fabrics one and two approximated their initial recordings, while the check had a much higher rate of compression than its original. Between the tenth and twentieth launderings fabric two increased, fabric three slightly decreased while fabrics one and four showed significant decrease in compressibility. After the twentieth laundering, the brown and grey twill was 4 per cent and the check was $16\frac{1}{2}$ per cent more resistant, while the black and white twill and the herringbone were approximately 7 per cent less resistant in their compressibility than they were initially (See Table XVIII in the appendix). The brown and white herringbone showed less radical changes in compressibility at specified testing intervals than the other three fabrics.

During dry cleaning, fabrics one, two and four varied widely in their compressibility; while fabric three, as in laundering, varied little. Following the fifth dry cleaning fabric one had slightly increased, three slightly decreased and fabrics two and four showed considerable decrease in compressibility. After five additional dry cleanings the black and white twill, the herringbone and the check increased slightly in their compressibility, while the brown and grey twill was significantly more resistant to compression. During the remaining ten dry cleanings fabrics two, three and four again decreased in compressibility while fabric one increased. At the conclusion of the study fabric three was slightly higher, fabrics two and four much lower and fabric one approximately the same as they were initially.

The suitings showed a wider variation in their rate of compression at the testing intervals during the sequence of dry cleanings than during corresponding launderings. It was of interest that the black and white twill was more resistant to compression than the other three suitings during dry cleanings.

COMPRESSIONAL RESILIENCE

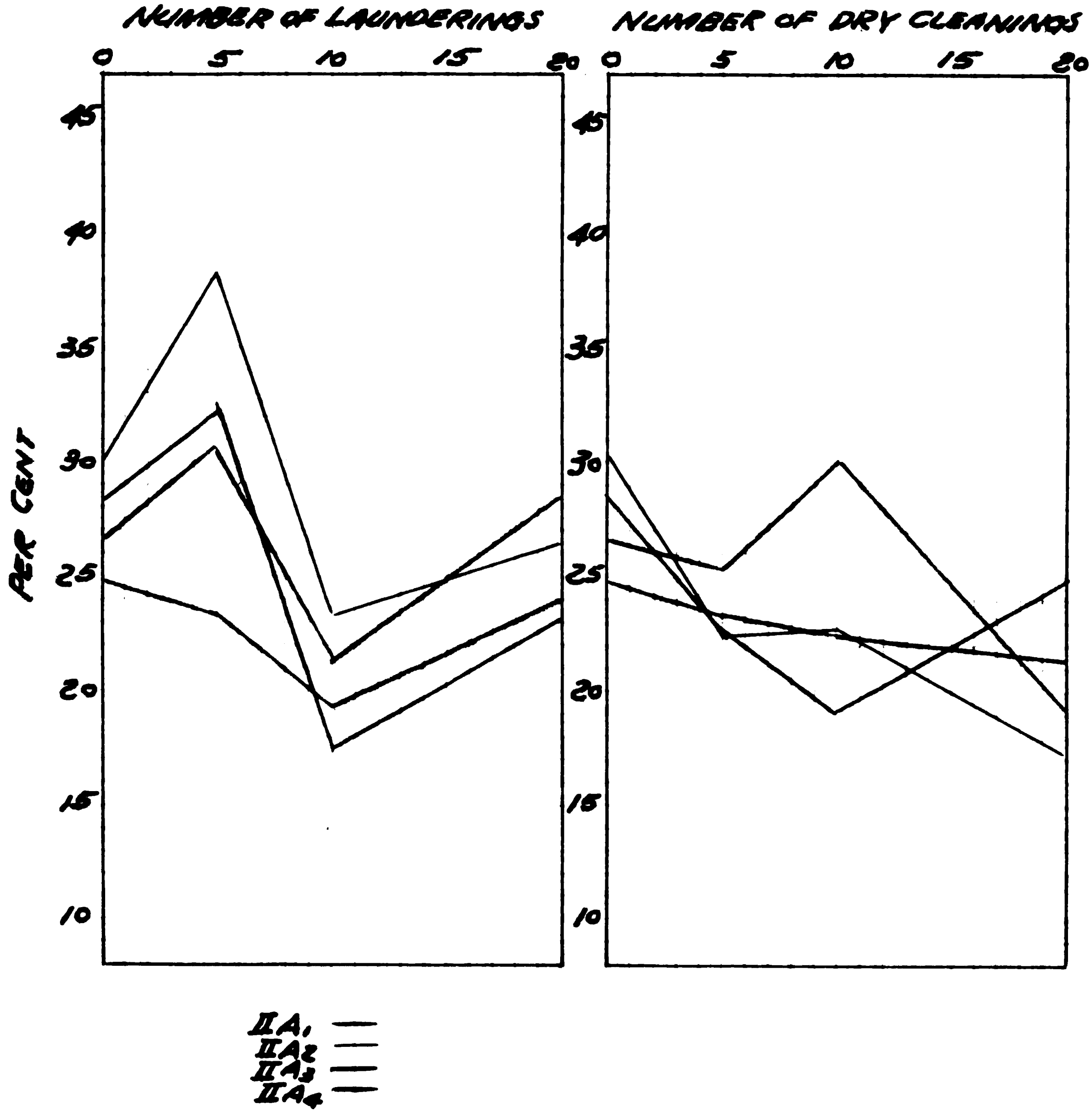
After the fifth laundering, fabrics one, two and three had improved in compressional resilience by 15, 26 and 13 per cent respectively while the fourth fabric, the check, had decreased 6 per cent (See Table XIX in the appendix). A noticeable loss in compressional resilience was seen following the next five launderings, ranging from a 20 to 38 per cent, with three fabrics averaging a change of 21 per cent. Each fabric showed significant improvement in the subsequent ten launderings (See Plate XIX, page 122). At the termination of the study, fabric one had increased 7½ per cent, while fabrics two, three and four were now 13, 18 and 3 per cent respectively below their original compressional resilience values.

The four fabrics decreased in compressional resilience in the first five dry cleanings, but thereafter the changes in their behavior was dissimilar. At the tenth dry cleaning, the brown and grey twill (number 1) increased 12 per cent while fabrics two, three and four had lost 25, 33 and 9 per cent in their compressional resilience compared with initial values. At the end of the study, numbers one and two had

PLATE XIX

COMPRESSIONAL RESILIENCE

IIA



decreased 28 and 43 per cent while fabrics three and four had similarly decreased 13 per cent.

Due to both increase and decrease in compressional resilience during twenty launderings and dry cleanings, the average per cent change for the group could not be considered typical of any one fabric within the group.

TENSILE STRENGTH

The warp dry strength which had averaged 71 pounds during the initial breaks was approximately 3 pounds lower after five and 2 pounds lower after ten and twenty launderings (See Table XXI in the appendix). The warp wet strengths averaged 1 pound less at each successive testing interval. Therefore, after twenty launderings the four suitings approximated 38.8 pounds in warp wet strength as compared to their 41.7 pounds initially. Fabrics two, three and four were similar in their warp (wet and dry) tensile strengths after specified launderings and the average of the group could be considered typical for each of the three fabrics (See Plate XX, page 124). On the other hand, the average of the group could not be considered typical for the brown and grey twill for it had warp (wet and dry) tensile strength 4 to 7 pounds lower than the other three fabrics. During laundering, warp wet strengths were approximately 56 to 59 per cent of dry strength.

Launderings showed little effect upon the filling (wet and dry) for the fabrics varied from their initial strength--only 1 or 2 pounds at the subsequent testing intervals. One

PLATE XX

BREAKING STRENGTH

II A

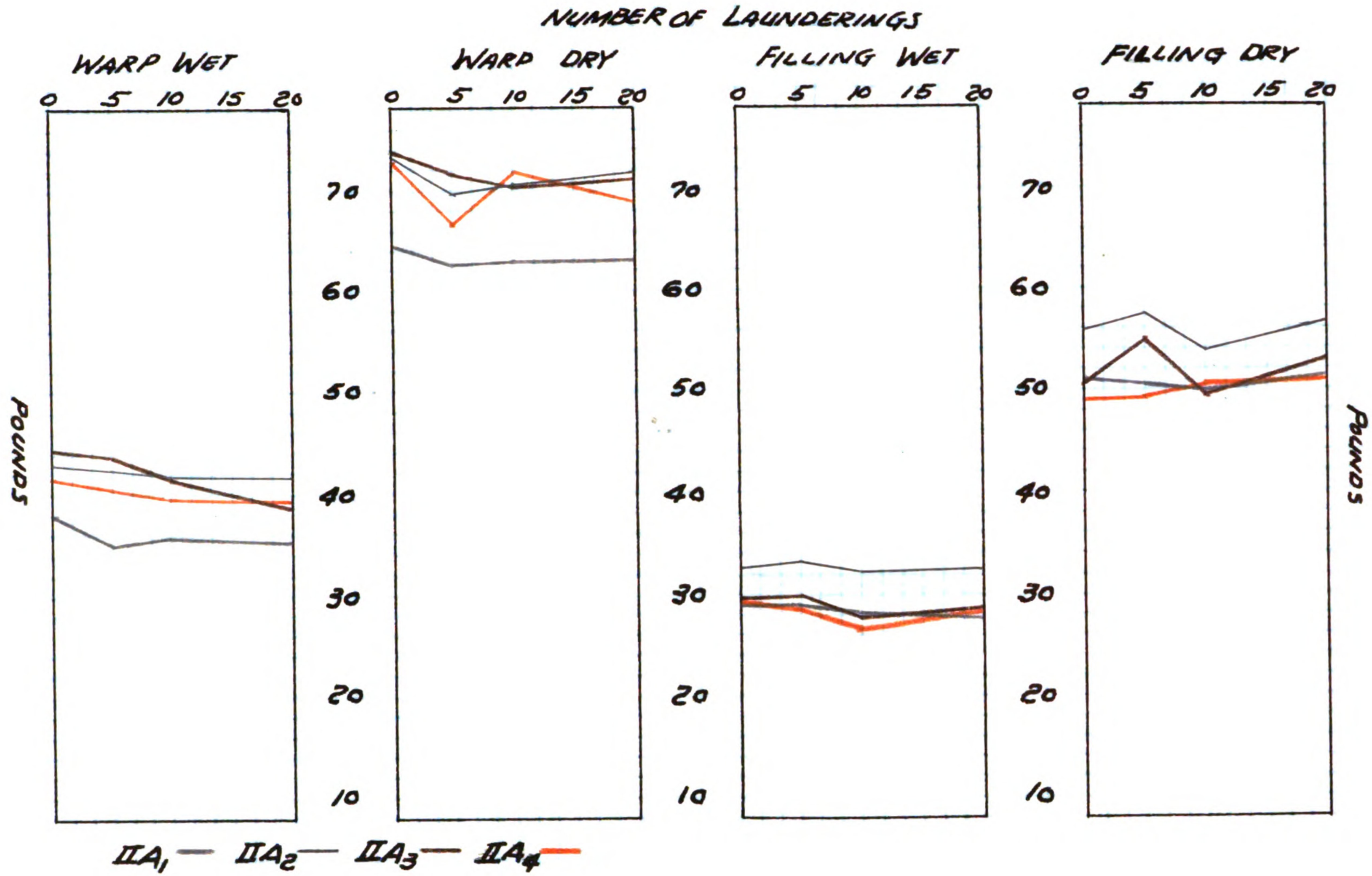
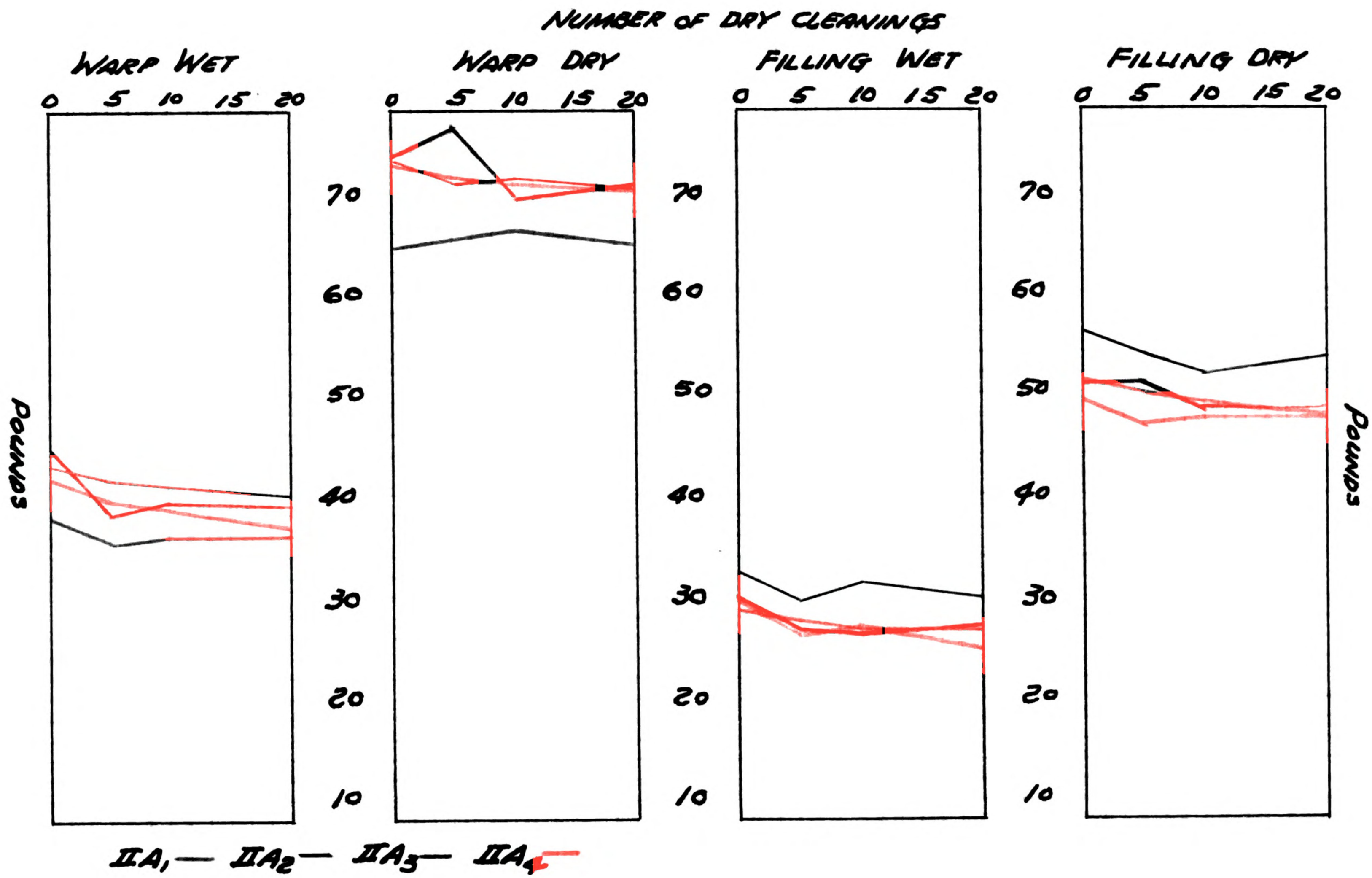


PLATE XXI

BREAKING STRENGTH

IIA



exception was the brown and white herringbone which increased in filling dry strength after five launderings but thereafter was similar to fabrics one and four. IIA_2, the black and white twill was 3 or 4 pounds stronger in the filling (wet and dry) than the other three fabrics which had similar strength. The wet filling strength determinations were approximately 57 per cent of their dry strength at the various laundering intervals.

The warp (wet and dry) strengths, after specified dry cleanings, were similar to corresponding breaks during laundering (See Plate XXI, page 125). Fabric one, which was lower in warp tensile strength after either type of cleaning treatment was closer to the average breaks for the other three fabrics after twenty dry cleanings than after twenty launderings.

The filling (wet and dry) strength which was approximately the same throughout the launderings, decreased about 2 pounds after twenty dry cleanings. Fabrics one, three and four were similar in filling (wet and dry) strength after dry cleaning while the black and white twill was 2 to 4 pounds stronger.

ELONGATION

In general, the four fabrics in both warp and filling had approximately the same per cent of elongation at each specific testing interval (See Plates XXII and XXIII, pages 127 and 128). Wet elongation was slightly greater than dry at each testing.

PLATE XXII

ELONGATION

IIA

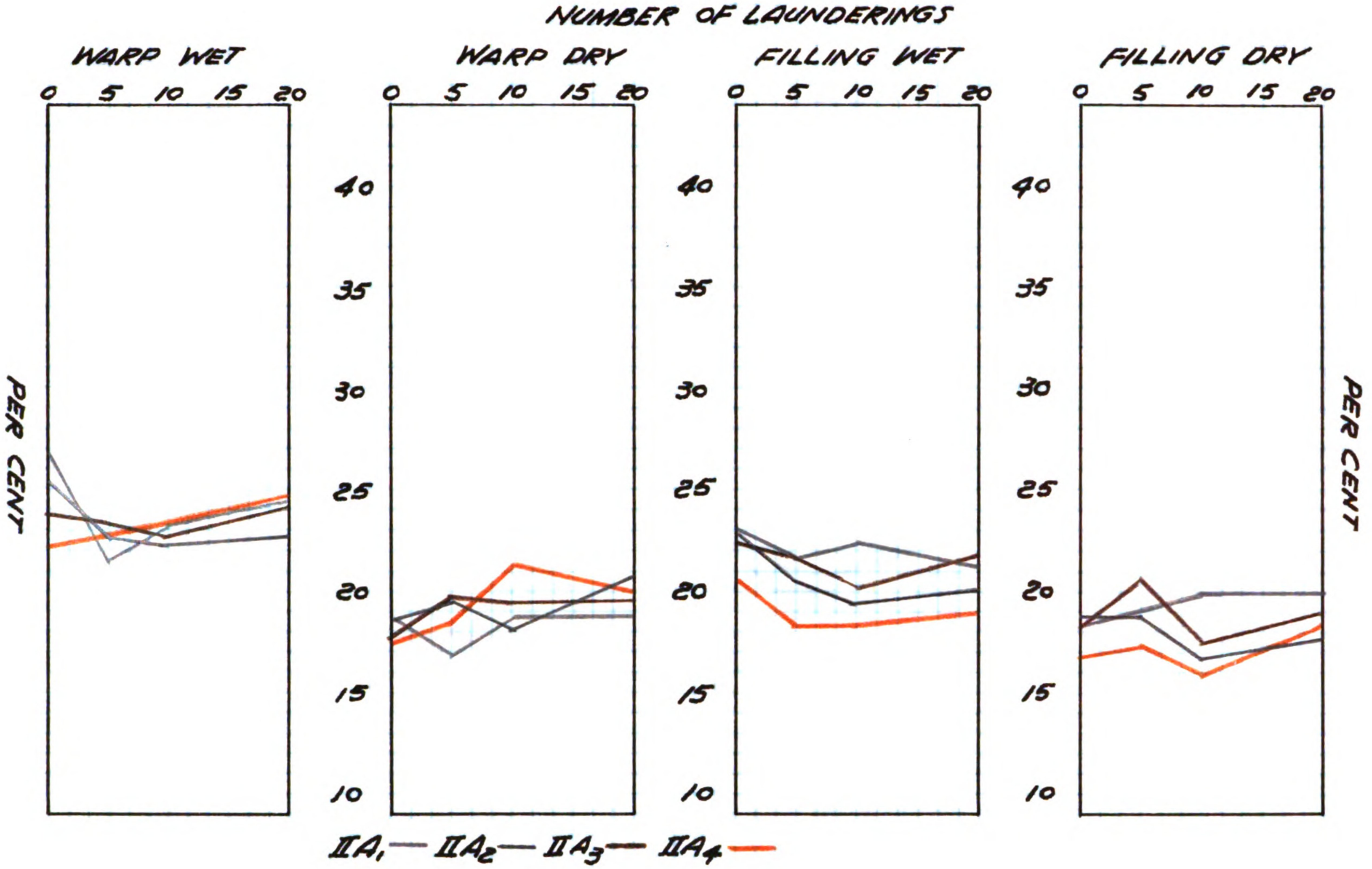
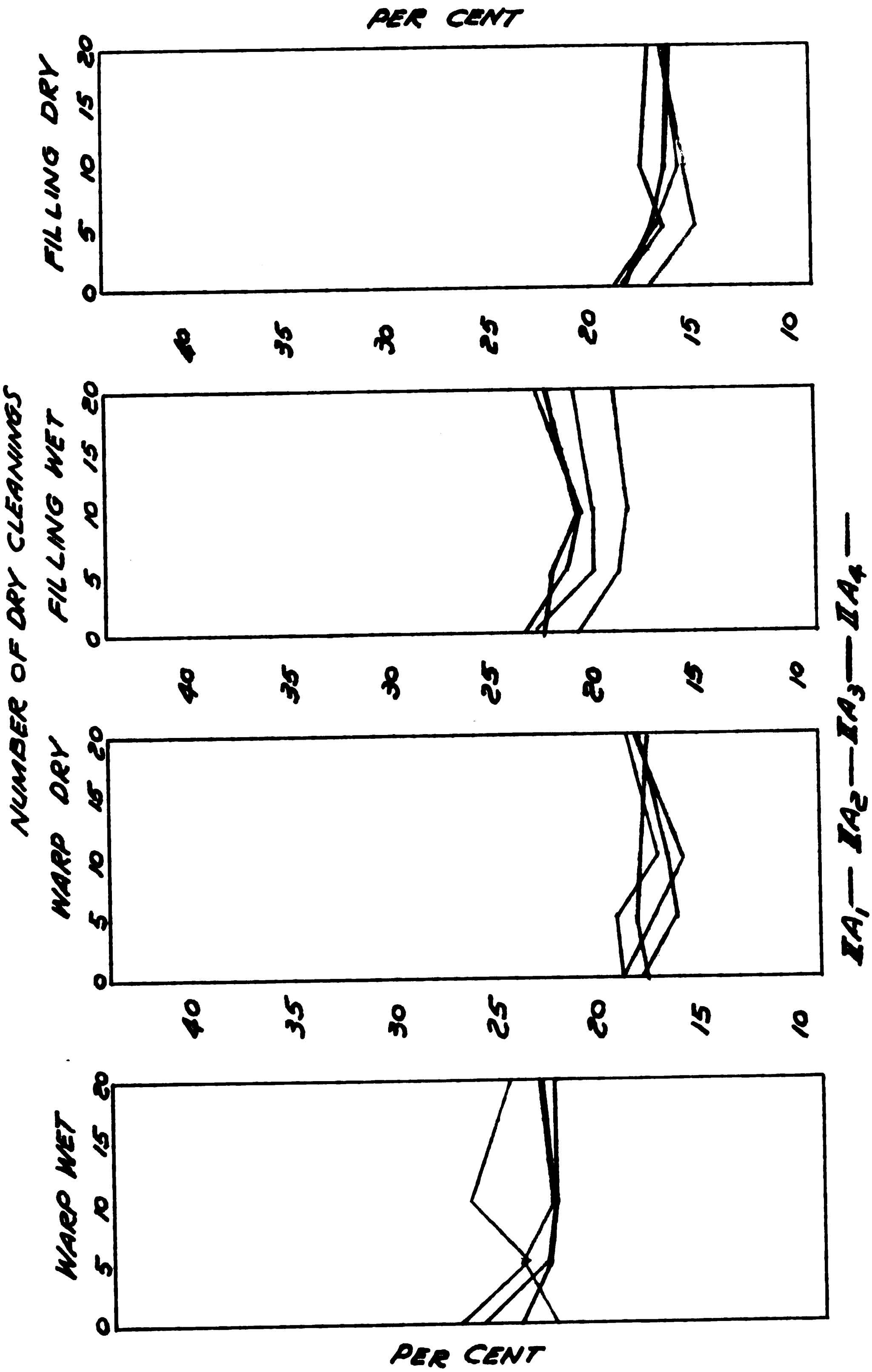


PLATE XXIII

ELONGATION

IIA



Dry determinations in the warp and filling had similar elongation at specific laundering intervals. Likewise, after a specified number of dry cleanings, each fabric elongated approximately the same amount in both the warp and filling (See Table XXIII in the appendix). There was slight increase in elongation (dry) with continued launderings, but the fabrics tended to have less elongation after additional dry cleanings.

The warp showed greater elongation (wet) than the filling irrespective of the cleaning treatment. As the dry cleanings and launderings progressed the wet determinations for both warp and filling elongation tended to be lower.

ABRASION RESISTANCE

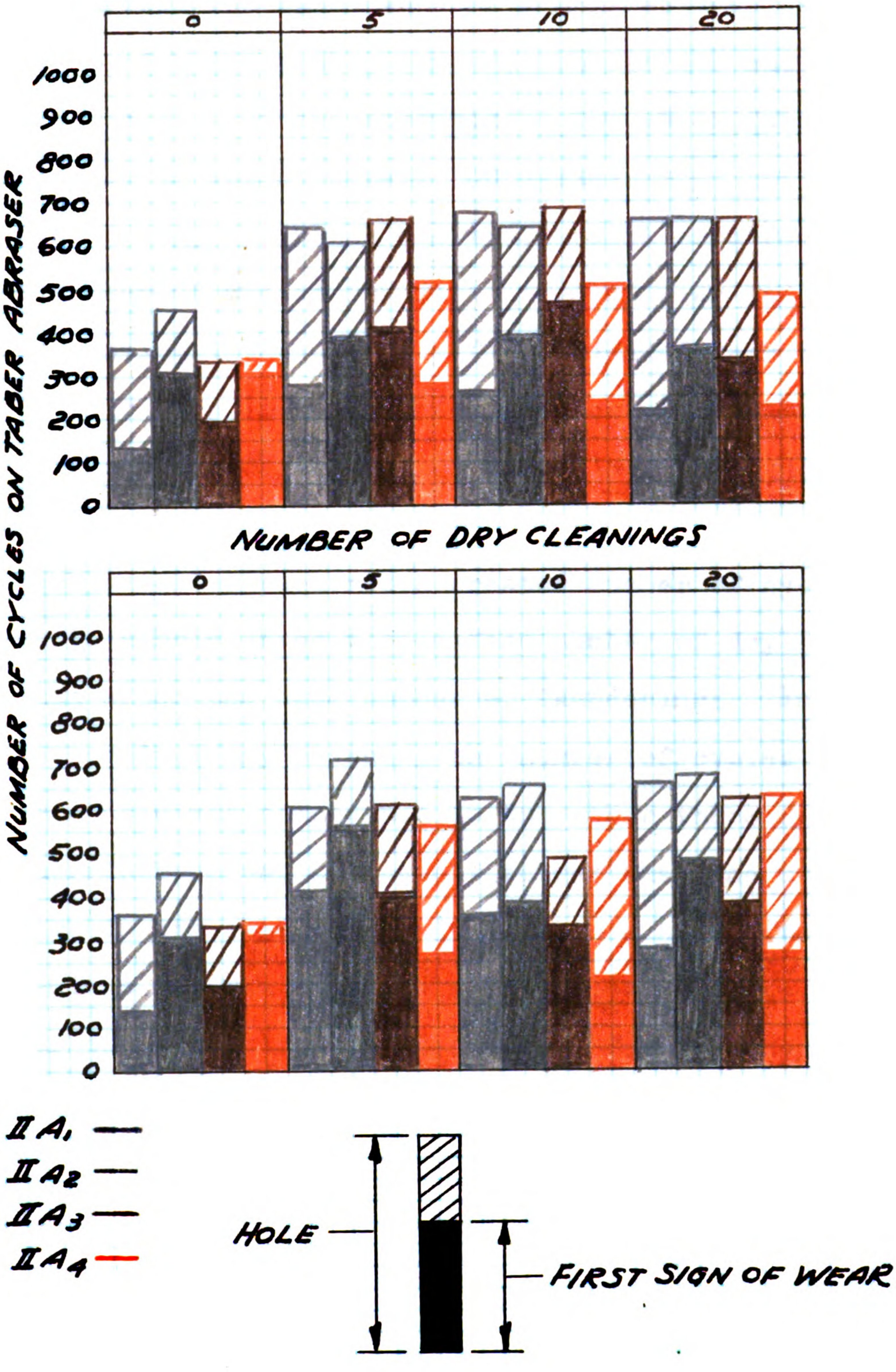
Fabrics one, two and three required more abrasing cycles for first sign of wear after launderings and dry cleanings than they did when new. Likewise each of the four fabrics after either cleaning treatment required a greater number of cycles before the appearance of a hole. (See Plate XXIV, page 130).

The two even-twill fabrics improved in their abrasion resistance for first sign of wear after five launderings, but showed less resistance through the remaining fifteen. The number of cycles required for first sign of wear in the herringbone twill increased during the first ten launderings but decreased thereafter. The checked fabric progressively decreased in its abrasion resistance with continuous launderings. Fabrics two and three were significantly more

PLATE XXIV

RESISTANCE TO ABRASION

IIA



resistant to first signs of wear than the other two fabrics.

The first three fabrics in this group required a similar number of cycles for appearance of a hole at each of the three laundering intervals; namely, between 600 and 700 cycles (See Table XXIV in the appendix). The check fabric abraded to a hole at approximately 500 cycles.

In dry cleaning, the black and white twill required the highest number of cycles for first sign of wear and hole at each testing interval. The first sign of wear was higher for fabrics one, two and three and lower for fabric four during repetitive dry cleanings as well as in laundering when compared to their controls.

The check material required a greater number of cycles for abrading to a hole after a specified number of dry cleanings than after the same number of launderings. In fact, at the terminal dry cleaning the number of cycles it required for a hole was comparable to the other three fabrics. The herringbone was noticeably poorer than the other three suitings in its abrasion resistance to a hole after ten dry cleanings but was comparable to the other three fabrics after the remaining ten cleanings. Fabrics one and two required between 600 and 700 cycles for a hole during dry cleanings; fabric three being comparable after the fifth and twentieth dry cleaning while fabric four was comparable only at the termination of the study.

The fabrics in Group II were equivalent in abrasion resistance after a specified number of either launderings or dry cleanings. A similar amount of wear is seen in the three abraded specimens on Plate XXXV in the appendix. The same is true as shown in the photographs in Plate XXXVI. The originals, subjected to a lower number of abrasion cycles are just as badly worn as the laundered and dry cleaned specimens abraded an additional 225 to 325 cycles.

The suitings improved in abrasion resistance during the first five in both cleaning treatments but changed little thereafter. This is illustrated (Plates XXXV and XXXVI) by the specimens laundered and dry cleaned five times as compared to those subjected to the cleaning treatments twenty times. The four are equivalent in their wear as well as number of cycles required for a hole.

COLORFASTNESS TO LIGHT

Fabrics one, two and three showed (Class 3) no appreciable change in color after 40 hours exposure in the Fade-Ometer after the fifth, tenth and twentieth laundering (See Table XXV in the appendix).

After the fifth and tenth dry cleaning, fabrics one and three were likewise rated Class 3 but at the tenth dry cleaning interval, fabric two dropped from Class 3 to Class 2 (no appreciable color change after 20 hours exposure). After twenty dry cleanings fabrics one and three were rated as Class 2 and fabric two which had shown steady decrease in resistance to fading dropped to Class 1. Fabric four was superior in that its classification of 4 with no appreciable color change after 80 hours of exposure was maintained at each successive laundering and dry cleaning interval.

COLORFASTNESS TO LAUNDERING AND DRY CLEANING

No color change could be detected at the specified intervals during either of the cleaning treatments.

A COMPARISON OF FABRIC PERFORMANCE IN LAUNDERING AND DRY CLEANING

Fabrics constituting Group I were erratic in performance with an unacceptable amount of warp shrinkage in both laundering and dry cleaning procedures. Minimal stretchage and shrinkage occurred in the filling during successive launderings, while a 3 to 4 per cent filling shrinkage was measured after twenty dry cleanings.

The suitings shrank through the first five launderings and maintained approximately the same dimensions thereafter. Their filling shrinkage was nearly equivalent to that of the warp, which was decidedly different than the noticeably uneven shrinkage of the dress weight gabardines.

After twenty cleaning treatments the warp in the laundered and the filling of the dry cleaned suitings had shrunk approximately 3 per cent. It is very possible that they could have been somewhat restored to their original dimensions during laundering for they were handled with care so not to alter their maximum change.

In general, the fabrics increased in weight with repetitive launderings and dry cleanings. The per cent increase for the group of suitings was less than that for the gabardines because of less shrinkage.

Generally speaking, an increase in thickness occurred in the gabardines with successive launderings and dry cleanings. None of the suitings showed much change during the first ten launderings, but the brown and grey twill and the herringbone had a noticeable thickness increase during the last ten. The herringbone had thickened by approximately 16 per cent which was comparable to that of the gabardines. During dry cleanings, the even-faced twill suitings changed little in thickness while the herringbone and check had greater increases which approximated the per cent change of the gabardines. Thickness increases in the group of suitings between the last two testing intervals correlates with their warp shrinkage in the last ten launderings and both warp and filling shrinkage during the corresponding dry cleanings.

Increased yarn count paralleled shrinkage. Change was negligible in the warp of the gabardines during launderings, but there were 7 to 8 per cent more yarns per inch fillingwise due to excessive warp shrinkage. The suitings increased only 1 per cent in the warp and 3 per cent in the filling during laundering. During the twenty dry cleanings the gabardines increased only 2 per cent in the warp yarn count while the filling count increased 7 per cent. Warp and filling yarn counts in the suitings were only $2\frac{1}{2}$ and 3 per cent greater than the control fabrics.

The gabardines showed higher drapability than the suitings during the original testing and increased in this characteristic during the sequence of launderings and dry

cleanings. The check suiting, which was the stiffest in the initial testing, increased more in drapability at the laundering intervals than the other three suitings. In fact, its percentage change was comparable to that in the gabardines. IIA_2 and IIA_4 which were the stiffest suitings before cleaning treatments had as much increase in their drapability after the tenth and twentieth dry cleanings as the gabardines at the corresponding intervals.

There was significant improvement in wrinkle recovery both warpwise and fillingwise in the dress weight gabardines during laundering, and even greater recovery in dry cleaning. On the other hand, there was only slight improvement in wrinkle recovery in the laundered suitings. During dry cleanings, they showed very small increases in warp wrinkle recovery and practically no change in the filling. It was of interest that the gabardines which had low initial recovery values when compared to Group II were equivalent to the suitings in both warp and filling wrinkle recovery at the terminal dry cleaning.

Each fabric in this study was erratic in compressibility. However, the suitings as a group displayed more similarity in this performance test than the gabardines. After the fifth laundering, the suitings compressed more rapidly than the gabardines but the opposite was true at the following interval. By the time the twenty launderings had been completed, the eight fabrics in this study showed similarity to the controls as well as to each other in

compressibility. The only change in the suitings after dry cleanings was a slightly lower rate of compression. However, the gabardines increased in compressibility after five dry cleanings with an even greater increase after ten. By the twentieth dry cleaning, their performance was comparable to that after the corresponding laundering. At this time their compressibility was similar to the originals and to that of the suitings.

The gabardines which were dissimilar in original compressional resilience were much alike after launderings and dry cleanings. All of the fabrics were erratic in their performance but the gabardines were less predictable than the suitings. In general, the fabrics decreased in resilience but the yellow made a noticeable improvement at each testing interval. At the termination of the study the resilience of the gabardines was equivalent after either type of treatment, but the suitings were more resilient after laundering than after dry cleaning. As a result the suitings were superior to Group I after launderings and vice versa after dry cleanings.

Each fabric varied little from its control in tensile strength and showed slight variation from the group average after a specified number of either cleaning treatment. The gabardines had greater warp strength after dry cleaning than after laundering. Due to negligible filling shrinkage and stretchage, the warp lost strength during laundering. Warp shrinkage in both cleaning treatments increased strength fillingwise. The tensile strength in Group II decreased in both cleaning procedures except for a slight gain in the filling after five launderings. After dry cleaning, the warp wet and the filling (wet and dry) strengths were lower than after corresponding launderings.

Elongation in the fabrics was slightly affected by the cleaning treatments. At the termination of the study the per cent elongation for each of the eight fabrics was similar to its original elongation. An exception was seen in the green fabric which after twenty launderings had 8.3 per cent less warp dry elongation than its control.

Both groups improved in their abrasion resistance with Group I showing a greater increase than Group II. An exception was the number of cycles required for a hole after five of either cleaning treatment. At this interval Group II had more abrasion resistance than Group I. The gabardines were more resistant after ten and twenty launderings than after the same number of dry cleanings. It was of interest that both groups improved similarly in the number of cycles required for a hole at the various dry cleaning intervals.

Colorfastness to light of the suitings was acceptable while the gabardines were commercially unacceptable in either cleaning treatment. The gabardines significantly bled in color during the early launderings but no change in color was observed during dry cleaning. The suitings showed no color change resulting from either type of cleaning.

CONCLUSIONS

Based on the interpretation of the laboratory test data in this study, the following fabric characteristics may be considered significant.

1. The individual gabardine fabrics were significantly different in weight, thickness, wrinkle recovery, compressional resilience and abrasion resistance despite comparable yarn and weave structure.
2. The greige or untreated gabardine differed significantly from the treated fabrics in yarn specifications and yarn count. It was dissimilar in the initial functional performance tests but showed progressive and more comparable performance after repetitive laundering.
3. The four suiting fabrics unlike in weave structure showed greater similarity in their initial compressional resilience and wrinkle recovery than the gabardine fabrics.
4. Results of initial performance testing are as follows:
    - (a) Drapability of the dress weight gabardines was superior to that of the suitings.
    - (b) The suitings recovered from wrinkling to a much higher degree both warp and fillingwise than the gabardines.
    - (c) The initial compressibility of the eight fabrics was similar.
    - (d) The gabardines as a group averaged higher

compressional resilience than the suitings, but showed greater variance among the individual fabrics.

(e) Higher and more equalized warp and filling breaking strength was seen in Group II as compared to Group I.

(f) At all times, greater elongation and lower breaking strength characterized the wet determinations.

(g) The suitings showed equivalent performance in both the warp and filling while the dress weight gabardines had approximately one-third greater elongation in warp than in filling.

(h) Abrasion resistance for first sign of wear was low for all eight fabrics.

(i) The suitings were acceptable and the gabardines unacceptable in their colorfastness to light.

(j) The initial warp wrinkle recovery of the gabardines was unacceptable in spite of the converter's claim that the fabric had been treated for this purpose. The claim made for the suitings was validated by test.

5. Results of testing after laundering and dry cleaning:

(a) The gabardine fabrics lost their surface resin in both laundering and dry cleaning. Each fabric showed excessive shrinkage irrespective of the cleaning treatment. The pink had the greatest weight and thickness changes after both cleaning treatments. The green changed the least in thickness during launderings while the yellow acted similarly during dry cleaning. The yellow gabardine did not change its superior draping qualities or greater wrinkle recovery. However, a significant disadvantage of this fabric was its low tensile strength. During dry cleaning, the brown was seen to be the superior fabric as far as performance was concerned. It had the best drapability, wrinkle recovery and the highest resistance to abrasion for either first sign of wear or a hole. It ranked highest or next to the highest in breaking strength during all the testing.

(b) The significant quality of the suitings was their ability to retain original performance characteristics throughout launderings and dry cleanings. Their shrinkage was much less than that of the gabardines. Their drapability and wrinkle recovery somewhat improved, while their thickness and weight only slightly increased. Compressibility was a little lower after cleaning treatments. Compressional resilience improved after five launderings but otherwise was lower than the original recordings. Each fabric displayed erratic behavior

in the compressibility and compressional resilience testing. Tensile strength (wet and dry) and the corresponding elongations were only slightly affected by successive cleaning treatments. Abrasion resistance improved during the first five cleaning treatments, but showed little change thereafter. All the suitings had good colorfastness to light and cleaning treatments.

6. The retention or permanence of the finish applied to the suitings may be due to the looser yarn and weave structure which permitted better penetration of the resin although other variables as curing time and temperature may likewise have influenced its permanence.
7. Performance testing results show that the applied finishes were more effective throughout repetitive dry cleanings than in successive launderings.
8. Due to excessive shrinkage and fading, none of the four fabrics in Group I could be recommended to the consumer-buyer as completely satisfactory. However, in spite of its low initial wrinkle recovery fabric IA_3 (brown) was superior in performance when dry cleaned and would be rated as the best fabric in this group.
9. The suitings cost \$.93 per square yard more than the gabardines. In spite of this higher initial cost they were superior in initial and terminal

performance testing. Each fabric could be recommended to the consumer-buyer.

10. Because the "greige" fabric had not been shrunk its physical characteristics were unlike the treated gabardines. For further studies it is recommended that a length of fully shrunk, dyed fabric without a resin treatment be used as the basis for comparison. In this study, shrinkage and sizing interfered to such an extent that valid conclusions showing the effect of a resin treatment could not be obtained.

11. It would be significant in the future to study the relationship between yarn and weave structure and the permanence of the resin treatment. The resins and conditions of treatment in this study were not revealed. Therefore, no comparisons due to yarn and weave structure could be made.

SUMMARY

The purpose of this study was to evaluate specifications and compare the physical characteristics and functional performance of two groups of crush resistant treated rayon fabrics. Each group contained four fabrics which were evaluated for initial effectiveness in crush resistance and other characteristics and the extent and rate of change that occurred after a specified number of launderings and dry cleanings.

Four dress weight gabardines alike except in color comprised the first group and four suitings unlike in weave structure constituted the second group. A length of the dress weight gabardine in the "greige" was used for comparison with the "finished" gabardine fabrics.

The eight original fabrics were analyzed in the laboratory for initial specifications and performance characteristics under standard ASTM methods, instruments and conditions for testing. Fiber identification, analysis of yarn structure--size and twist, weave analysis, yarn count, weight, thickness, compressibility, compressional resilience, wrinkle recovery, drapability, tensile strength and elongation, abrasion resistance and colorfastness to light were the tests made. Performance testing was repeated after the fifth, tenth and twentieth laundering and dry cleaning for determination of changes in the above characteristics in each of the cleaning procedures. Also, the degree and rate of change resulting from twenty launderings and dry cleanings

were determined.

One half of the specimens were laundered in the Atlas Launder-Ometer at 105° F. and pressed so as to minimize dimensional change. The others were dry cleaned at a commercial establishment in East Lansing with a petroleum base cleaning fluid and pressed with a steam presser. Dimensions were taken after the first, second, third, fifth, tenth and twentieth launderings and following the fifth, tenth and twentieth dry cleanings.

Analysis of test data showed the four gabardines, supposedly identical except in color, to be significantly different in weight and thickness and comparably different in their initial performance. The gabardine fabrics were poorly balanced in weave structure.

The four suitings in Group II were heavier and thicker and had a better balanced yarn count even though they were selected primarily for their appearance value effected through yarn, weave and color variation.

Excessive warp shrinkage occurred in both laundering and dry cleaning the gabardines with minimum residual area change in the suitings. Generally speaking, the thicknesses and weight per square yard of the fabrics paralleled their shrinkage.

Original crease resistance values of two of the gabardines was below the commercially acceptable standard. Each was acceptable after repetitive launderings and dry cleanings. The suitings had higher and better balanced crease resistance

values initially and retained their effectiveness in crease resistance during the entire sequence of laundering and dry cleaning.

The gabardines had better initial draping qualities and showed improvement during laundering and dry cleaning. The suitings, which were firmer and less drapable originally, showed less improvement.

The fabrics were erratic in both compressibility and compressional resilience testing. There was such variance in the rate of compression of the individual fabrics that group averages were not typical of any one fabric. The suitings showed less change in compressibility after either cleaning treatment than the gabardines.

Compressional resilience was lower after repetitive launderings and dry cleanings; the suitings showing less loss in resilience than the gabardines.

The eight fabrics showed only slight changes in tensile strength and elongation. In general, significant improvement in abrasion resistance occurred after five launderings and dry cleanings with only slight change occurring during the remaining fifteen cleaning treatments.

The gabardines showed excessive bleeding of color during laundering and significantly poor colorfastness to light. The suitings were superior in colorfastness to light and both types of cleaning.

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LITERATURE CITED

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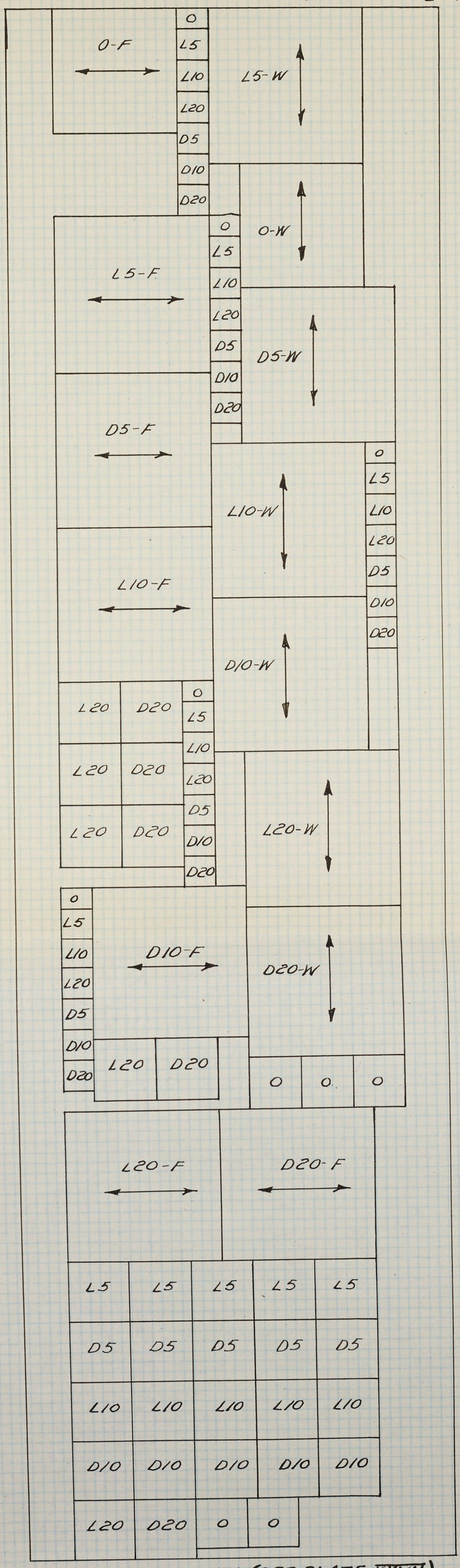
APPENDIX

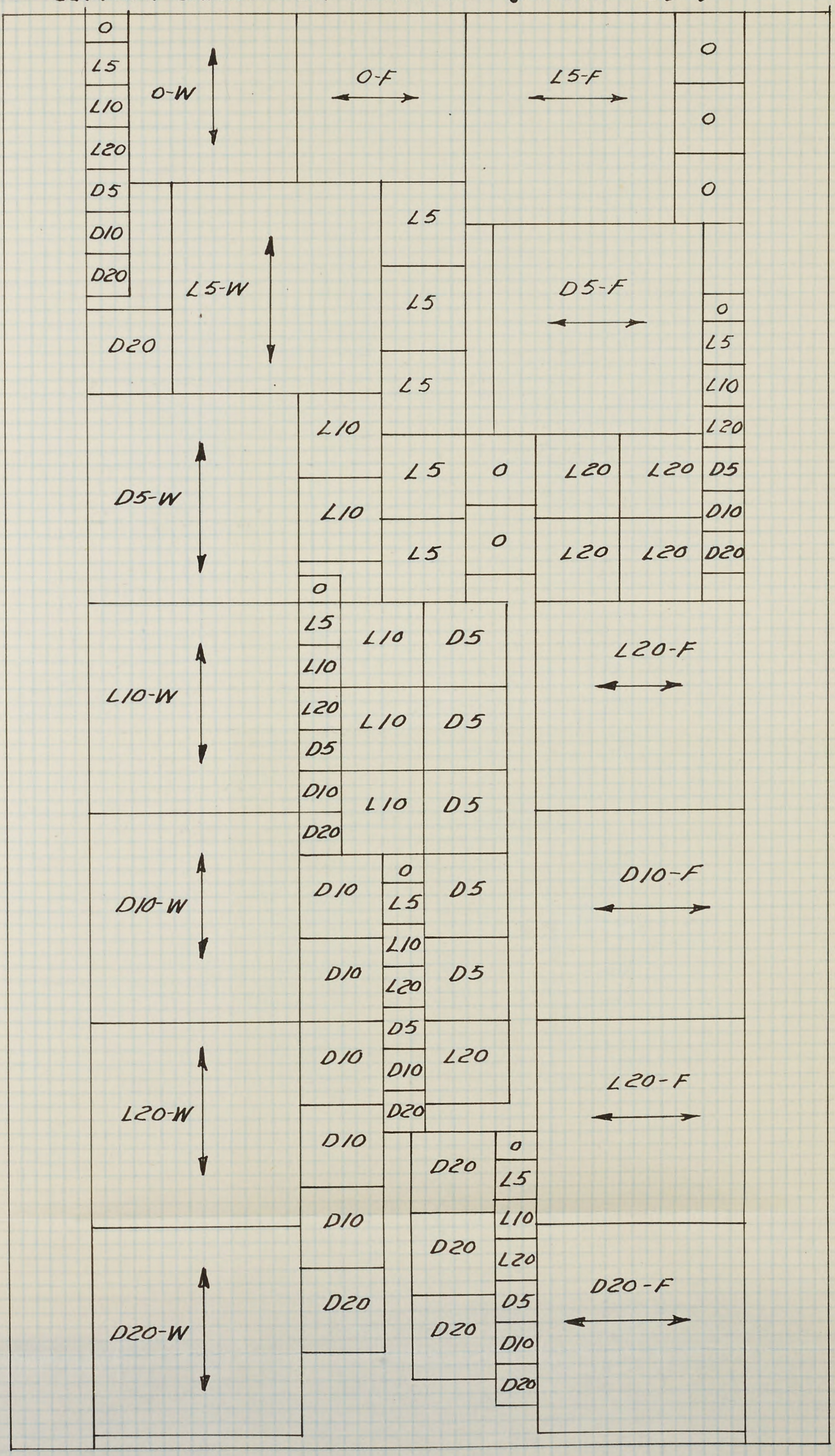
PLATE XXV
CUTTING CHART FOR DRESS
WEIGHT GABARDINES (WIDTH - 41½")



W = WARP TESTED (SEE PLATE XXVII)
F = FILLING TESTED (SEE PLATE XXVII)
L = WITHDRAWN AFTER LAUNDERINGS
D = WITHDRAWN AFTER DRY CLEANINGS
5" X 5" = ABRASION TEST - ORIGINAL
6" X 6" = ABRASION TEST - AFTER LAUNDERINGS AND DRY CLEANINGS
3" X 2" = WEIGHT PER SQUARE YARD - ORIGINAL
3" X 3" = WEIGHT PER SQUARE YARD - AFTER LAUNDERINGS AND DRY CLEANINGS
12" X 12" = DRAPABILITY, TENSILE STRENGTH, WRINKLE RECOVERY (SEE PLATE XXVII)
15" X 15" = DRAPABILITY, TENSILE STRENGTH, WRINKLE RECOVERY (SEE PLATE XXVII)

PLATE XXVI

CUTTING CHART FOR SUITINGS (WIDTH - 59")



W = WARP TESTED (SEE PLATE XXVII)
F = FILLING TESTED (SEE PLATE XXVII)
L = WITHDRAWN AFTER LAUNDERINGS
D = WITHDRAWN AFTER DRY CLEANINGS
5" x 5" = ABRASION TEST - ORIGINAL
6" x 6" = ABRASION TEST - AFTER LAUNDERINGS AND DRY CLEANINGS
3" x 2" = WEIGHT PER SQUARE YARD - ORIGINAL
3" x 3" = WEIGHT PER SQUARE YARD - AFTER LAUNDERINGS AND DRY CLEANINGS
12" x 12" = DRAPABILITY, TENSILE STRENGTH, WRINKLE RECOVERY (SEE PLATE XXVII)
15" x 15" = DRAPABILITY, TENSILE STRENGTH, WRINKLE RECOVERY (SEE PLATE XXVII)

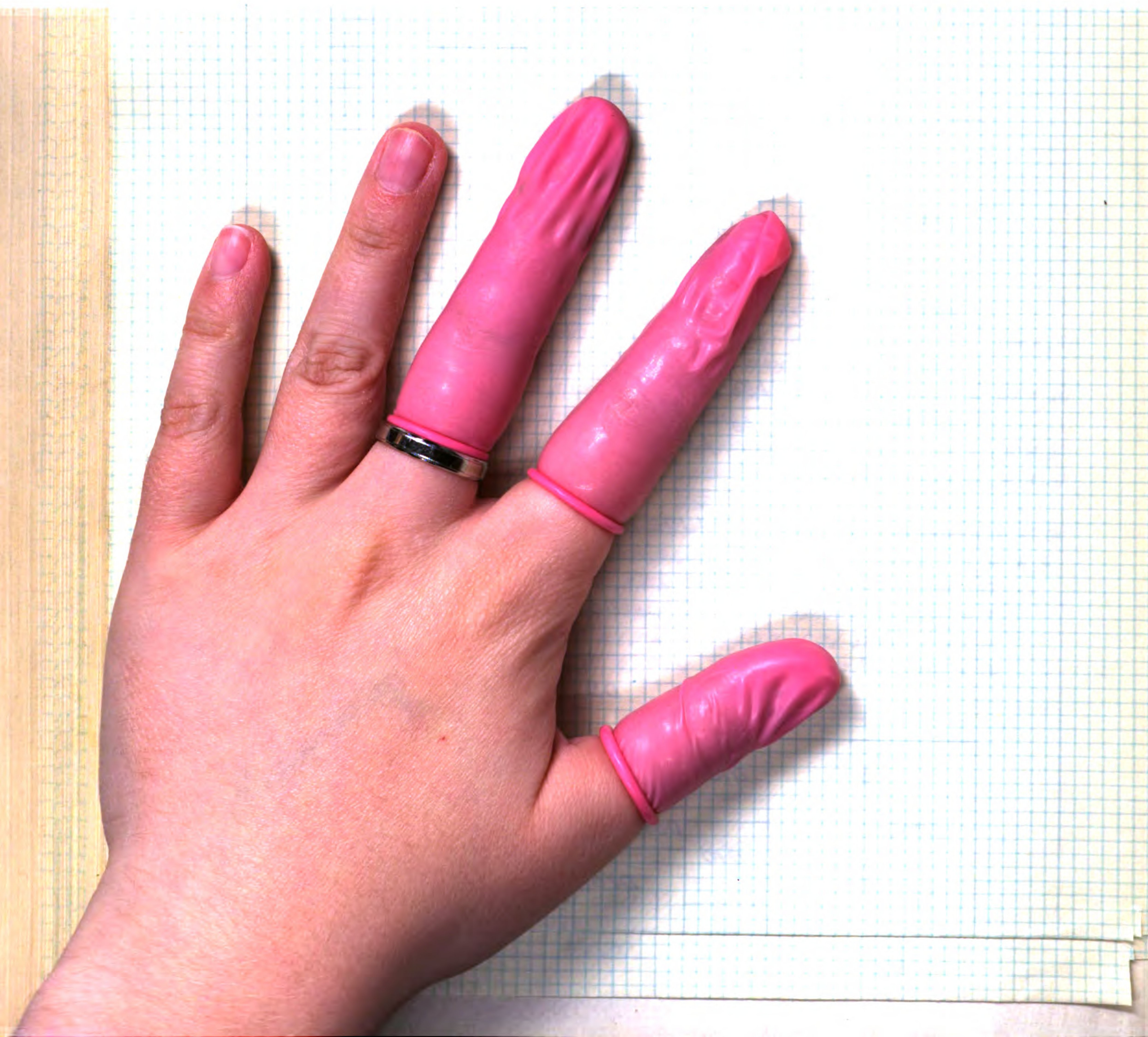


PLATE XXVII

DETAIL OF SAMPLING FOR ORIGINAL, LAUNDERED AND DRY CLEANED SQUARES.

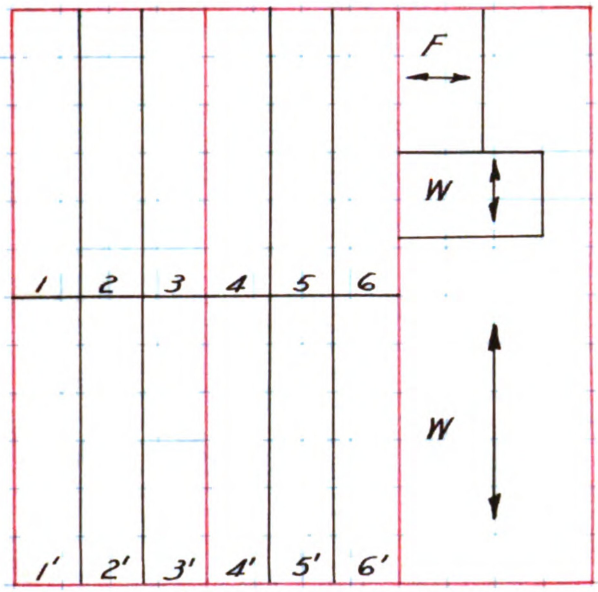


FIGURE A

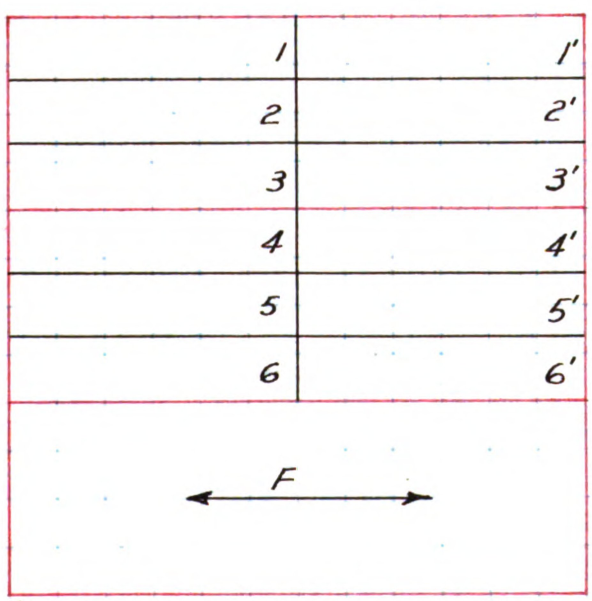


FIGURE B

4" X 12" = (———)
DRAPABILITY
(FOLDED 4" X 10" WHEN TESTED)

$1\frac{1}{3}$" X 6" = TENSILE STRENGTH

3" X $1\frac{3}{4}$" = WRINKLE RECOVERY
(CUT INTO FIVE $1\frac{1}{2}$ CM. X 4 CM. SPECIMENS)

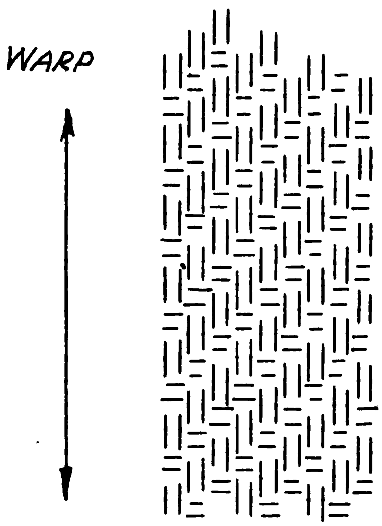
1 = DRY TENSILE STRENGTH

1' = WET TENSILE STRENGTH

PLATE XXVIII

WEAVE GRAPH

IA



IA_1 —

IA_2

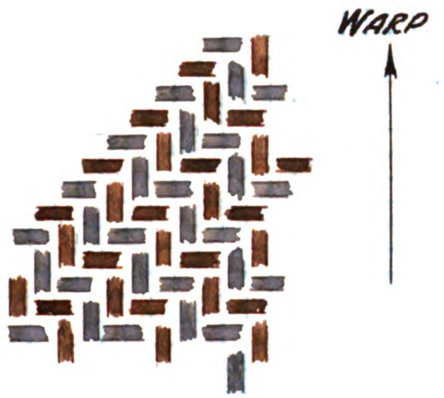
IA_3 —

IA_4 —

IA_5 —

PLATE XXIX
WEAVE GRAPH

IIA1



IIA2

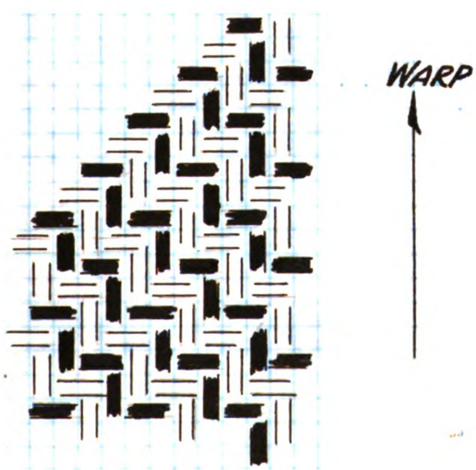
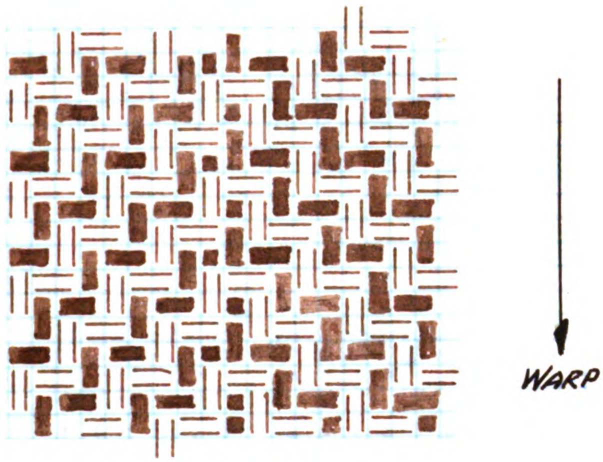


PLATE XXX

WEAVE GRAPH

IIA3



IIA4

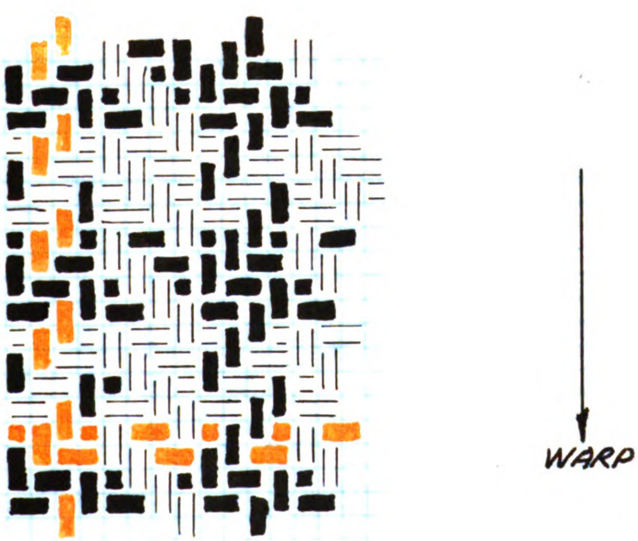


TABLE X
PERCENTAGE DIMENSIONAL CHANGE

		After Launderings						After Dry Cleanings		
		After 1	After 2	After 3	After 5	After 10	After 20	After 5	After 10	After 20
IA Warp	1	- 6.25	- 6.88	- 3.75	- 8.12	- 6.56	- 7.81	- 4.36	- 5.29	- 6.86
	2	- 5.64	- 6.90	- 4.39	- 7.21	- 7.52	- 8.14	- 3.75	- 2.19	- 5.94
	3	- 5.97	- 6.60	- 4.09	- 7.22	- 3.46	- 7.86	- 4.06	- 4.68	- 6.56
	4	- 5.64	- 6.58	- 4.08	- 7.20	- 4.08	- 8.14	- 4.08	- 5.00	- 6.90
	*5	-11.60	-14.10	-11.60	-14.73	-14.73	-15.04	- 1.88	- 3.14	- 4.08
Average		- 5.88	- 6.74	- 4.08	- 7.44	- 5.40	- 7.99	- 4.06	- 4.29	- 6.56
IA Filling	1	+ 1.25	+ .31	+ 3.75	--	+ .62	+ .31	- 2.17	- 2.17	- 4.34
	2	+ 1.25	+ .94	+ 3.12	+ .62	+ 1.25	+ .62	- 1.24	- .62	- 2.80
	3	- .31	+ .31	+ 1.56	- .94	+ 2.19	- .94	- 1.24	- 1.25	- 3.44
	4	+ .31	+ .62	+ 1.88	- .31	+ 1.88	- .62	- 1.25	- 1.56	- 3.12
	*5	- 2.82	- 2.82	- .62	- 3.44	- 2.19	- 2.82	- 1.56	- 2.50	- 4.70
Average		+ .62	+ .54	+ 2.58	- .16	+ 1.48	- .16	- 1.48	- 1.40	- 3.42
IIA Warp	1	- 1.86	- 2.18	- 2.48	- 3.11	- 2.80	- 3.74	- 1.56	- 2.19	- 2.50
	2	- 2.50	- 2.50	- 2.81	- 3.12	- 2.50	- 3.44	- 2.19	- 2.19	- 2.81
	3	- 1.56	- 1.88	- 2.50	- 3.12	- 2.81	- 3.12	- 1.24	- 2.18	- 2.49
	4	- 1.56	- 1.88	- 2.20	- 3.46	- 2.83	- 2.84	- 1.25	- 1.88	- 2.50
Average		- 1.87	- 2.11	- 2.50	- 3.20	- 2.74	- 3.28	- 1.56	- 2.11	- 2.58
IIA Filling	1	- 1.86	- 1.86	- 2.17	- 2.79	- 2.17	- 2.17	- 1.25	- 2.19	- 2.81
	2	- 1.87	- 1.87	- 1.87	- 1.87	- 1.56	- 1.87	- 1.87	- 2.49	- 3.74
	3	- .94	- .62	- 1.25	- 1.25	- .94	- .94	- 1.25	- 1.88	- 2.50
	4	- .62	- .31	- .62	- .94	--	- .31	- .94	- 1.88	- 3.14
Average		- 1.32	- 1.16	- 1.48	- 1.71	- 1.17	- 1.32	- 1.33	- 2.11	- 3.05

*IA5 not included in calculations
Each is an average of 10 measurements
Measured to the nearest 16th of an inch

TABLE XI
WEIGHT PER SQUARE YARD IN OUNCES

		Original	After 5	Difference	% change	After 10	Difference	% change	After 20	Difference	% change
		After Launderings									
IA	1	5.5683	5.9901	+.4218	+ 7.58	6.0339	+.4656	+ 8.36	6.1562	+.5879	+10.56
	2	5.7176	5.9478	+.2302	+ 4.03	6.1590	+.4414	+ 7.72	6.1813	+.4637	+ 8.11
	3	5.7366	5.9496	+.2130	+ 3.71	6.0095	+.2729	+ 4.76	6.1610	+.4244	+ 7.40
	4	5.9229	6.0499	+.1270	+ 2.14	6.1763	+.2534	+ 4.28	6.3269	+.4040	+ 6.82
	*5	5.2994	6.2348	+.9354	+17.65	6.2806	+.9812	+18.52	6.1818	+.8824	+16.65
Average		5.7364	5.9844	+.2480	+ 4.32	6.0947	+.3583	+ 6.25	6.2064	+.4700	+ 8.19
IA		**After Dry Cleanings**									
	1	5.5683	5.9812	+.4129	+ 7.42	6.1798	+.6115	+10.98	6.4776	+.9093	+16.33
	2	5.7176	6.0477	+.3301	+ 5.77	5.9796	+.2620	+ 4.58	6.3162	+.5986	+10.47
	3	5.7366	6.0339	+.2973	+ 5.18	6.1059	+.3693	+ 6.44	6.4298	+.6932	+12.08
	4	5.9229	6.0161	+.0932	+ 1.57	6.1788	+.2559	+ 4.32	6.5180	+.5951	+10.05
	*5	5.2994	5.4603	+.1609	+ 3.04	5.5599	+.2605	+ 4.92	5.7574	+.4580	+ 8.64
Average		5.7364	6.0197	+.2833	+ 4.94	6.1110	+.3746	+ 6.53	6.4354	+.6990	+12.19
IIA		**After Launderings**									
	1	6.6236	6.9545	+.3309	+ 5.00	6.9150	+.2914	+ 4.40	7.0800	+.4564	+ 6.89
	2	7.1573	7.5159	+.3586	+ 5.01	7.5531	+.3958	+ 5.53	7.5330	+.3757	+ 5.25
	3	6.7191	6.8896	+.1705	+ 2.54	6.9411	+.2220	+ 3.30	7.0631	+.3440	+ 5.12
	4	6.9687	7.1426	+.1739	+ 2.50	7.2064	+.2377	+ 3.41	7.2118	+.2431	+ 3.49
Average		6.8672	7.1256	+.2584	+ 3.76	7.1539	+.2867	+ 4.17	7.2220	+.3548	+ 5.17
IIA		**After Dry Cleanings**									
	1	6.6236	6.7895	+.1659	+ 2.50	6.8965	+.2729	+ 4.12	7.1778	+.5542	+ 8.37
	2	7.1573	7.4690	+.3117	+ 4.35	7.5415	+.3842	+ 5.37	7.7142	+.5569	+ 7.78
	3	6.7191	6.8034	+.0843	+ 1.25	6.8117	+.0926	+ 1.38	7.1017	+.3826	+ 5.69
	4	6.9687	7.0983	+.1296	+ 1.86	7.2798	+.3111	+ 4.46	7.3227	+.3540	+ 5.08
Average		6.8672	7.0400	+.1728	+ 2.52	7.1324	+.2652	+ 3.86	7.3291	+.4619	+ 6.73

*IA_5 not included in calculations

TABLE XII
THICKNESS (INCH)

		Original	After Launderings After 5	Dif-ference	% change	After 10	Dif-ference	% change	After 20	Dif-ference	% change
IA											
	1	.0199	.0217	+.0018	+ 9.05	.0235	+.0036	+18.09	.0235	+.0036	+18.09
	2	.0206	.0201	-.0005	- 2.43	.0223	+.0017	+ 8.25	.0234	+.0028	+13.59
	3	.0215	.0224	+.0009	+ 4.19	.0234	+.0019	+ 8.84	.0243	+.0028	+13.02
	4	.0219	.0231	+.0012	+ 5.48	.0231	+.0012	+ 5.48	.0247	+.0028	+12.79
	*5	.0210	.0239	+.0029	+13.81	.0255	+.0045	+21.43	.0247	+.0037	+17.62
Average		.0210	.0218	+.0008	+ 3.81	.0231	+.0021	+10.00	.0240	+.0030	+14.29
			After Dry Cleanings								
IA	1	.0199	.0219	+.0020	+10.05	.0217	+.0018	+ 9.05	.0225	+.0026	+13.07
	2	.0206	.0222	+.0016	+ 7.77	.0214	+.0008	+ 3.88	.0219	+.0013	+ 6.31
	3	.0215	.0228	+.0013	+ 6.05	.0226	+.0011	+ 5.12	.0259	+.0044	+20.47
	4	.0219	.0238	+.0019	+ 8.68	.0233	+.0014	+ 6.39	.0249	+.0030	+13.70
	*5	.0210	.0226	+.0016	+ 7.62	.0216	+.0006	+ 2.86	.0208	-.0002	- .95
Average		.0210	.0227	+.0017	+ 8.10	.0222	+.0012	+ 5.71	.0238	+.0028	+13.33
			After Launderings								
IIA	1	.0238	.0234	-.0004	- 1.68	.0239	+.0001	+ .42	.0259	+.0021	+ 8.82
	2	.0259	.0254	-.0005	- 1.93	.0251	-.0008	- 3.09	.0265	+.0006	+ 2.32
	3	.0228	.0231	+.0003	+ 1.32	.0233	+.0005	+ 2.19	.0264	+.0036	+15.79
	4	.0249	.0247	-.0002	- .80	.0242	-.0007	- 2.81	.0254	+.0005	+ 2.01
Average		.0244	.0242	-.0002	- .82	.0241	-.0003	- 1.23	.0260	+.0016	+ 6.56
			After Dry Cleanings								
IIA	1	.0238	.0251	+.0013	+ 5.46	.0246	+.0008	+ 3.36	.0246	+.0008	+ 3.36
	2	.0259	.0271	+.0012	+ 4.63	.0270	+.0011	+ 4.25	.0253	-.0006	- 2.32
	3	.0228	.0248	+.0020	+ 8.77	.0250	+.0022	+ 9.65	.0255	+.0027	+11.84
	4	.0249	.0264	+.0015	+ 6.02	.0259	+.0010	+ 4.02	.0274	+.0025	+10.04
Average		.0244	.0258	+.0014	+ 5.74	.0256	+.0012	+ 4.92	.0257	+.0013	+ 5.33

*IA_5 not included in calculations

TABLE XIII
YARN COUNT

After Launderings

	Original	After 5	Difference	% change	After 10	Difference	% change	After 20	Difference	% change
IA Warp 1	111	109	- 2	- 1.80	110	- 1	- .90	110	- 1	- .90
2	109	108	- 1	- .92	109	0	---	110	+ 1	+ .92
3	110	109	- 1	- .91	109	- 1	- .91	109	- 1	- .91
4	109	108	- 1	- .92	109	0	---	109	0	---
*5	106	110	+ 4	+ 3.77	111	+ 5	+ 4.72	110	+ 4	+ 3.77
Average	110	108	- 2	- 1.82	109	- 1	- .91	110	0	---
IA Filling 1	56	61	+ 5	+ 8.93	62	+ 6	+ 10.71	61	+ 5	+ 8.93
2	56	60	+ 4	+ 7.14	62	+ 6	+ 10.71	61	+ 5	+ 8.93
3	55	59	+ 4	+ 7.27	60	+ 5	+ 9.09	60	+ 5	+ 9.09
4	55	61	+ 6	+ 10.91	61	+ 6	+ 10.91	62	+ 7	+ 12.73
*5	52	62	+ 10	+ 19.23	63	+ 11	+ 21.15	62	+ 10	+ 19.23
Average	56	60	+ 4	+ 7.14	61	+ 5	+ 8.93	61	+ 5	+ 8.93

After Dry Cleanings

	Original	After 5	Difference	% change	After 10	Difference	% change	After 20	Difference	% change
IA Warp 1	111	114	+ 3	+ 2.70	113	+ 2	+ 1.80	114	+ 3	+ 2.70
2	109	111	+ 2	+ 1.83	110	+ 1	+ .92	113	+ 4	+ 3.67
3	110	111	+ 1	+ .91	110	---	---	113	+ 3	+ 2.73
4	109	110	+ 1	+ .92	110	+ 1	+ .92	113	+ 4	+ 3.67
*5	106	108	+ 2	+ 1.89	109	+ 3	+ 2.83	111	+ 5	+ 4.72
Average	110	112	+ 2	+ 1.82	111	+ 1	+ .91	113	+ 3	+ 2.73
IA Filling 1	56	59	+ 3	+ 5.36	59	+ 3	+ 5.36	61	+ 5	+ 8.93
2	56	59	+ 3	+ 5.36	58	+ 2	+ 3.57	59	+ 3	+ 5.36
3	55	57	+ 2	+ 3.64	57	+ 2	+ 3.64	59	+ 4	+ 7.27
4	55	59	+ 4	+ 7.27	58	+ 3	+ 5.45	61	+ 6	+ 10.91
*5	52	54	+ 2	+ 3.85	55	+ 3	+ 5.77	56	+ 4	+ 7.69
Average	56	58	+ 2	+ 3.57	58	+ 2	+ 3.57	60	+ 4	+ 7.14

*IA_5 not included in calculations
Each is an average of 5 determinations

TABLE XIV
YARN COUNT

		After Launderings									
		Original	After 5	Difference	% change	After 10	Difference	% change	After 20	Difference	% change
IIA Warp	1	79	81	+ 2	+ 2.53	81	+ 2	+ 2.53	80	+ 1	+ 1.27
	2	80	81	+ 1	+ 1.25	81	+ 1	+ 1.25	81	+ 1	+ 1.25
	3	80	81	+ 1	+ 1.25	81	+ 1	+ 1.25	80	0	--
	4	80	81	+ 1	+ 1.25	80	0	--	80	0	--
Average		80	81	+ 1	+ 1.25	81	+ 1	+ 1.25	80	0	--
IIA Filling	1	60	62	+ 2	+ 3.33	62	+ 2	+ 3.33	62	+ 2	+ 3.33
	2	65	66	+ 1	+ 1.54	66	+ 1	+ 1.54	67	+ 2	+ 3.08
	3	60	62	+ 2	+ 3.33	62	+ 2	+ 3.33	62	+ 2	+ 3.33
	4	63	65	+ 2	+ 3.17	65	+ 2	+ 3.17	65	+ 2	+ 3.17
Average		62	64	+ 2	+ 3.23	64	+ 2	+ 3.23	64	+ 2	+ 3.23
		After Dry Cleanings									
IIA Warp	1	79	80	+ 1	+ 1.27	80	+ 1	+ 1.27	81	+ 2	+ 2.53
	2	80	81	+ 1	+ 1.25	82	+ 2	+ 2.50	83	+ 3	+ 3.75
	3	80	81	+ 1	+ 1.25	81	+ 1	+ 1.25	83	+ 3	+ 3.75
	4	80	81	+ 1	+ 1.25	82	+ 2	+ 2.50	83	+ 3	+ 3.75
Average		80	81	+ 1	+ 1.25	81	+ 1	+ 1.25	82	+ 2	+ 2.50
IIA Filling	1	60	60	--	--	61	+ 1	+ 1.67	62	+ 2	+ 3.33
	2	65	66	+ 1	+ 1.54	66	+ 1	+ 1.54	67	+ 2	+ 3.08
	3	60	61	+ 1	+ 1.67	61	+ 1	+ 1.67	63	+ 3	+ 5.00
	4	63	64	+ 1	+ 1.59	65	+ 2	+ 3.17	66	+ 3	+ 4.76
Average		62	63	+ 1	+ 1.61	63	+ 1	+ 1.61	64	+ 2	+ 3.23

Each is an average of 5 determinations

TABLE XV
DRAPABILITY

	Original	After 5	Difference	% change	After 10	Difference	% change	After 20	Difference	% change
		After Launderings								
IA										
1	45	36	- 9	-20.00	43	- 2	- 4.44	32	- 13	-28.89
2	44	33	- 11	-25.00	37	- 7	-15.91	33	- 11	-25.00
3	47	37	- 10	-21.28	39	- 8	-17.02	38	- 9	-19.15
4	45	37	- 8	-17.78	40	- 5	-11.11	41	- 4	- 8.89
*5	41	53	+ 12	+29.27				39	- 2	- 4.88
Average	45	36	- 9	-20.00	40	- 5	-11.11	36	- 9	-20.00
		After Dry Cleanings								
IA 1	45	35	- 10	-22.22	32	- 13	-28.89	38	- 7	-15.56
2	44	43	- 1	- 2.27	32	- 12	-27.27	37	- 7	-15.91
3	47	31	- 16	-34.04	28	- 19	-40.43	35	- 12	-25.53
4	45	34	- 11	-24.44	36	- 9	-20.00	38	- 7	-15.56
*5	41	48	+ 7	+17.07				41	--	--
Average	45	36	- 9	-20.00	32	- 13	-28.89	37	- 8	-17.78
		After Launderings								
IIA 1	50	52	+ 2	+ 4.00	50	--	--	47	- 3	- 6.00
2	57	50	- 7	-12.28	52	- 5	- 8.77	49	- 8	-14.04
3	56	50	- 6	-10.71	51	- 5	- 8.93	47	- 9	-16.07
4	58	50	- 8	-13.79	44	- 14	-24.14	47	- 11	-18.97
Average	55	50	- 5	- 9.09	49	- 6	-10.91	48	- 7	-12.73
		After Dry Cleanings								
IIA 1	50	52	+ 2	+ 4.00	48	- 2	- 4.00	46	- 4	- 8.00
2	57	52	- 5	- 8.77	46	- 11	-19.30	47	- 10	-17.54
3	56	52	- 4	- 7.14	48	- 8	-14.29	49	- 7	-12.50
4	58	50	- 8	-13.79	46	- 12	-20.69	48	- 10	-17.24
Average	55	52	- 3	- 5.45	47	- 8	-14.55	48	- 7	-12.73

*IA_5 not included in calculations
The square root of warp X filling, each of which is the average of 3 determinations

TABLE XVI
WRINKLE RECOVERY VALUES

	Original	After 5	Difference	% change	After 10	Difference	% change	After 20	Difference	% change
After Launderings										
IA Warp 1	103	122	+ 19	+ 18.45	137	+ 34	+ 33.01	130	+ 27	+ 26.21
2	109	128	+ 19	+ 17.43	130	+ 21	+ 19.27	132	+ 23	+ 21.10
3	95	128	+ 33	+ 34.74	137	+ 42	+ 44.21	130	+ 35	+ 36.84
4	96	126	+ 30	+ 31.25	133	+ 37	+ 38.54	139	+ 43	+ 44.79
*5	46	110	+ 64	+139.13	120	+ 74	+160.87	130	+ 84	+182.61
Average	101	126	+ 25	+ 24.75	134	+ 33	+ 32.67	133	+ 32	+ 31.68
IA Filling 1	112	131	+ 19	+ 16.96	145	+ 33	+ 29.46	140	+ 28	+ 25.00
2	122	136	+ 14	+ 11.48	146	+ 24	+ 19.67	141	+ 19	+ 15.57
3	119	143	+ 24	+ 20.17	145	+ 26	+ 21.85	145	+ 26	+ 21.85
4	115	137	+ 22	+ 19.13	148	+ 33	+ 28.70	140	+ 25	+ 21.74
*5	105	141	+ 36	+ 34.29	137	+ 32	+ 30.48	142	+ 37	+ 35.24
Average	117	137	+ 20	+ 17.09	146	+ 29	+ 24.79	142	+ 25	+ 21.37
After Dry Cleanings										
IA Warp 1	103	133	+ 30	+ 29.13	144	+ 41	+ 39.81	138	+ 35	+ 33.98
2	109	136	+ 27	+ 24.77	136	+ 27	+ 24.77	147	+ 38	+ 34.86
3	95	135	+ 40	+ 42.11	146	+ 51	+ 53.68	150	+ 55	+ 57.89
4	96	131	+ 35	+ 36.46	145	+ 49	+ 51.04	146	+ 50	+ 52.08
*5	46	71	+ 25	+ 54.35	102	+ 56	+121.74	113	+ 67	+145.65
Average	101	134	+ 33	+ 32.67	143	+ 42	+ 41.58	145	+ 44	+ 43.56
IA Filling 1	112	140	+ 28	+ 25.00	136	+ 24	+ 21.43	152	+ 40	+ 35.71
2	122	140	+ 18	+ 14.75	138	+ 16	+ 13.11	147	+ 25	+ 20.49
3	119	143	+ 24	+ 20.17	140	+ 21	+ 17.65	153	+ 34	+ 28.57
4	115	142	+ 27	+ 23.48	148	+ 33	+ 28.70	152	+ 37	+ 32.17
*5	105	133	+ 28	+ 26.67	126	+ 21	+ 20.00	121	+ 16	+ 15.24
Average	117	141	+ 24	+ 20.51	140	+ 23	+ 19.66	151	+ 34	+ 29.06

*IA_5 not included in calculations
Each is an average of 5 determinations

TABLE XVII
WRINKLE RECOVERY VALUES

	Original	After 5	Difference	% change	After 10	Difference	% change	After 20	Difference	% change
After Launderings										
IIA Warp 1	145	145	--	--	150	+ 5	+ 3.45	156	+ 11	+ 7.59
2	148	155	+ 7	+ 4.73	153	+ 5	+ 3.38	161	+ 13	+ 8.78
3	140	156	+ 16	+ 11.43	154	+ 14	+ 10.00	149	+ 9	+ 6.43
4	141	158	+ 17	+ 12.06	152	+ 11	+ 7.80	158	+ 17	+ 12.06
Average	144	154	+ 10	+ 6.94	152	+ 8	+ 5.56	156	+ 12	+ 8.33
IIA Filling 1	150	150	--	--	143	- 7	- 4.67	145	- 5	- 3.33
2	150	145	- 5	- 3.33	147	- 3	- 2.00	153	+ 3	+ 2.00
3	145	151	+ 6	+ 4.14	146	+ 1	+ .69	154	+ 9	+ 6.21
4	152	159	+ 7	+ 4.61	148	- 4	- 2.63	158	+ 6	+ 3.95
Average	149	151	+ 2	+ 1.34	146	- 3	- 2.01	152	+ 3	+ 2.01
After Dry Cleaning										
IIA Warp 1	145	142	- 3	- 2.07	148	+ 3	+ 2.07	141	- 4	- 2.76
2	148	147	- 1	- .68	147	- 1	- .68	150	+ 2	+ 1.35
3	140	147	+ 7	+ 5.00	147	+ 7	+ 5.00	150	+ 10	+ 7.14
4	141	142	+ 1	+ .71	143	+ 2	+ 1.42	148	+ 7	+ 4.96
Average	144	144	--	--	146	+ 2	+ 1.39	147	+ 3	+ 2.08
IIA Filling 1	150	148	- 2	- 1.33	145	- 5	- 3.33	150	--	--
2	150	154	+ 4	+ 2.67	147	- 3	- 2.00	149	- 1	- .67
3	145	149	+ 4	+ 2.76	145	--	--	150	+ 5	+ 3.45
4	152	149	- 3	- 1.97	146	- 6	- 3.95	143	- 9	- 5.92
Average	149	150	+ 1	+ .67	146	- 3	- 2.01	148	- 1	- .67

Each is an average of 5 determinations

TABLE XVIII
COMPRESSIBILITY

		Original	After 5	Difference	% change	After 10	Difference	% change	After 20	Difference	% change
IA		After Launderings									
	1	.0553	.0476	- .0077	- 13.92	.0637	+ .0084	+ 15.19	.0538	- .0015	- 2.71
	2	.0550	.0546	- .0004	- .73	.0733	+ .0183	+ 33.27	.0655	+ .0105	+ 19.09
	3	.0619	.0551	- .0068	- 10.99	.0640	+ .0021	+ 3.39	.0509	- .0110	- 17.77
	4	.0623	.0492	- .0131	- 21.03	.0692	+ .0069	+ 11.08	.0621	- .0002	- .32
	*5	.0397	.0431	+ .0034	+ 8.56	.0483	+ .0086	+ 21.66	.0514	+ .0117	+ 29.47
Average		.0586	.0516	- .0070	- 11.95	.0676	+ .0090	+ 15.36	.0581	- .0005	- .85
IA		After Dry Cleanings									
	1	.0553	.0654	+ .0101	+ 18.26	.0752	+ .0199	+ 35.99	.0605	+ .0052	+ 9.40
	2	.0550	.0660	+ .0110	+ 20.00	.0808	+ .0258	+ 46.91	.0593	+ .0043	+ 7.82
	3	.0619	.0672	+ .0053	+ 8.56	.0664	+ .0045	+ 7.27	.0593	- .0026	- 4.20
	4	.0623	.0645	+ .0022	+ 3.53	.0813	+ .0190	+ 30.50	.0576	- .0047	- 7.54
	*5	.0397	.0604	+ .0207	+ 52.14	.0709	+ .0312	+ 78.59	.0498	+ .0101	+ 25.44
Average		.0586	.0658	+ .0072	+ 12.29	.0759	+ .0173	+ 29.52	.0592	+ .0006	+ 1.02
IIA		After Launderings									
	1	.0604	.0683	+ .0079	+ 13.08	.0613	+ .0009	+ 1.49	.0581	- .0023	- 3.81
	2	.0554	.0642	+ .0088	+ 15.88	.0571	+ .0017	+ 3.07	.0591	+ .0037	+ 6.68
	3	.0599	.0663	+ .0064	+ 10.68	.0659	+ .0060	+ 10.02	.0643	+ .0044	+ 7.35
	4	.0629	.0700	+ .0071	+ 11.29	.0566	- .0063	- 10.02	.0525	- .0104	- 16.53
Average		.0596	.0672	+ .0076	+ 12.75	.0602	+ .0006	+ 1.01	.0585	- .0011	- 1.85
IIA		After Dry Cleanings									
	1	.0604	.0625	+ .0021	+ 3.48	.0542	- .0062	- 10.26	.0610	+ .0006	+ .99
	2	.0554	.0480	- .0074	- 13.36	.0507	- .0047	- 8.48	.0487	- .0067	- 12.09
	3	.0599	.0592	- .0007	- 1.17	.0627	+ .0028	+ 4.67	.0615	+ .0016	+ 2.67
	4	.0629	.0543	- .0086	- 13.67	.0553	- .0076	- 12.08	.0498	- .0131	- 20.83
Average		.0596	.0560	- .0036	- 6.04	.0557	- .0039	- 6.54	.0552	- .0044	- 7.38

*IA_5 not included in calculations

TABLE XIX
COMPRESSIONAL RESILIENCE IN PER CENT

	Original	After 5	Difference	% change	After 10	Difference	% change	After 20	Difference	% change
		After Launderings								
IA										
1	36.48	40.27	+ 3.79	+10.39	28.75	- 7.73	-21.19	20.21	-16.27	-44.60
2	16.57	33.12	+16.55	+99.88	26.58	+10.01	+60.41	21.49	+ 4.92	+29.69
3	43.70	32.13	-11.57	-26.48	19.71	-23.99	-54.90	23.64	-20.06	-45.90
4	35.03	31.74	- 3.29	- 9.39	18.49	-16.54	-47.22	18.49	-16.54	-47.22
*5	23.78	28.79	+ 5.01	+21.07	28.03	+ 4.25	+17.87	29.46	+ 5.68	+23.89
Average	32.94	34.32	+ 1.38	+ 4.19	23.38	- 9.56	-29.02	20.96	-11.98	-36.37
		After Dry Cleanings								
IA 1	36.48	30.70	- 5.78	-15.84	20.90	-15.58	-42.71	22.04	-14.44	-39.58
2	16.57	31.30	+14.73	+88.90	19.27	+ 2.70	+16.29	25.44	+ 8.87	+53.53
3	43.70	33.07	-10.63	-24.32	16.52	-27.18	-62.20	17.07	-26.63	-60.94
4	35.03	31.08	- 3.95	-11.28	22.44	-12.59	-35.94	27.33	- 7.70	-21.98
*5	23.78	18.86	- 4.92	-20.69	23.73	- .05	- .21	13.00	-10.78	-45.33
Average	32.94	31.54	- 1.40	- 4.25	19.78	-13.16	-39.95	22.97	- 9.97	-30.27
		After Launderings								
IIA 1	26.75	30.79	+ 4.04	+15.10	21.25	- 5.50	-20.56	28.78	+ 2.03	+ 7.59
2	30.39	38.19	+ 7.80	+25.67	23.19	- 7.20	-23.69	26.49	- 3.90	-12.83
3	28.45	32.21	+ 3.76	+13.22	17.52	-10.93	-38.42	23.19	- 5.26	-18.49
4	24.98	23.41	- 1.57	- 6.29	19.27	- 5.71	-22.86	24.19	- .79	- 3.16
Average	27.64	31.15	+ 3.51	+12.70	20.31	- 7.33	-26.52	25.66	- 1.98	- 7.16
		After Dry Cleanings								
IIA 1	26.75	25.30	- 1.45	- 5.42	30.06	+ 3.31	+12.37	19.31	- 7.44	-27.81
2	30.39	22.58	- 7.81	-25.70	22.89	- 7.50	-24.68	17.29	-13.10	-43.11
3	28.45	22.76	- 5.69	-20.00	19.11	- 9.34	-32.83	24.69	- 3.76	-13.22
4	24.98	23.23	- 1.75	- 7.01	22.61	- 2.37	- 9.49	21.57	- 3.41	-13.65
Average	27.64	23.47	- 4.17	-15.09	23.67	- 3.97	-14.36	20.72	- 6.92	-25.04

*IA_5 not included in calculations

TABLE XX
BREAKING STRENGTH IN POUNDS

		After Launderings							
		Original		After 5		After 10		After 20	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
IA Warp	1	41.0	70.3	38.6	65.3	37.6	63.2	36.0	64.6
	2	35.8	64.6	37.8	66.0	36.9	57.3	35.5	60.3
	3	40.1	61.9	40.1	64.6	40.5	58.4	39.8	65.9
	4	38.2	60.5	40.5	60.9	38.2	64.7	38.4	63.7
	*5	36.6	67.6	35.8	62.0			37.9	62.5
Average		38.8	64.3	39.2	64.2	38.3	60.9	37.4	63.6
% change				+ 1.03	- .15	- 1.28	- 5.28	- 3.60	- 1.08
IA Filling	1	18.5	32.2	22.4	35.9	20.7	37.5	22.2	36.5
	2	17.5	28.8	18.8	32.2	20.9	36.1	19.3	33.6
	3	20.6	34.5	21.3	36.0	22.5	36.4	20.7	35.8
	4	24.2	41.8	23.1	39.6	23.6	37.7	22.0	36.5
	*5	18.0	32.8	21.8	38.8			21.8	35.5
Average		20.2	34.3	21.4	35.9	21.9	36.9	21.0	35.6
% change				+ 5.94	+4.66	+ 8.41	+ 7.58	+ 3.96	+ 3.79
		After Dry Cleanings							
IA Warp	1	41.0	70.3	41.1	69.3	39.5	71.9	38.3	69.2
	2	35.8	64.6	37.1	63.2	37.2	65.8	35.9	63.9
	3	40.1	61.9	42.0	67.8	41.1	68.3	40.0	65.4
	4	38.2	60.5	37.6	64.1	40.0	66.7	38.7	67.3
	*5	36.6	67.6	38.0	70.1			39.8	66.8
Average		38.8	64.3	39.4	66.1	39.4	68.2	38.2	66.4
% change				+ 1.54	+ 2.79	+1.54	+ 6.06	- 1.54	+ 3.26
IA Filling	1	18.5	32.2	22.8	39.0	21.5	35.2	21.3	34.2
	2	17.5	28.8	21.2	35.4	19.1	33.8	19.5	32.1
	3	20.6	34.5	23.7	38.6	21.6	35.8	20.7	34.2
	4	24.2	41.8	23.2	39.2	22.2	35.5	21.7	37.3
	*5	18.0	32.8	20.9	35.8			17.5	30.5
Average		20.2	34.3	22.7	38.0	21.1	35.1	20.8	34.4
% change				+12.37	+10.78	+ 4.45	+ 2.33	+ 2.97	+ .29

*IA_5 not included in calculations
Each is an average of 6 breaks
Ravelled Strip Method

TABLE XXI
BREAKING STRENGTH IN POUNDS

		After Launderings							
		Original		After 5		After 10		After 20	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
IIA Warp	1	38.0	64.7	35.2	62.5	35.9	62.9	35.4	63.2
	2	43.0	73.3	42.5	69.8	41.8	70.7	41.7	71.8
	3	44.2	73.8	43.8	71.7	41.7	70.5	38.6	71.2
	4	41.5	73.2	40.6	66.8	39.5	71.9	39.3	69.0
Average		41.7	71.2	40.5	67.7	39.7	69.0	38.8	68.8
% change				- 2.87	-4.91	- 4.79	- 3.08	- 6.95	- 3.37
IIA Filling	1	28.9	51.2	29.1	50.5	28.1	49.9	27.5	51.3
	2	32.5	55.9	33.2	57.4	32.2	53.9	32.3	56.5
	3	29.6	51.1	29.9	55.0	27.9	49.5	28.8	52.9
	4	29.1	49.2	28.8	49.2	26.7	50.7	28.4	51.0
Average		30.0	51.8	30.2	53.0	28.7	51.0	29.2	52.9
% change				+ .66	+2.31	- 4.33	- 1.54	- 2.66	+ 2.12
		After Dry Cleanings							
IIA Warp	1	38.0	64.7	35.5	65.6	36.2	66.3	36.2	64.8
	2	43.0	73.3	41.8	71.2	41.2	71.7	40.2	70.7
	3	44.2	73.8	38.1	74.4	39.6	69.4	39.2	70.8
	4	41.5	73.2	39.7	71.8	39.0	70.8	36.7	70.1
Average		41.7	71.2	38.8	70.8	39.0	69.6	38.1	69.1
% change				- 6.95	- .56	- 6.47	- 2.24	- 8.63	- 2.94
IIA Filling	1	28.9	51.2	27.8	50.0	27.0	49.0	26.6	47.8
	2	32.5	55.9	29.8	53.8	31.5	51.8	30.1	53.4
	3	29.6	51.1	27.1	50.9	26.5	48.4	27.0	48.0
	4	29.1	49.2	26.2	46.6	26.9	47.5	25.0	47.6
Average		30.0	51.8	27.7	50.3	28.0	49.2	27.2	49.2
% change				- 7.66	-2.89	- 6.66	- 5.01	- 9.33	- 5.01

Each is an average of 6 breaks
Ravelled Strip Method

TABLE XXII
ELONGATION

	Original Wet	Original Dry	After 5 Wet	After 5 Dry	After 10 Wet	After 10 Dry	After 20 Wet	After 20 Dry
After Launderings								
IA								
Warp 1	33.9	29.1	35.3	33.7	36.8	35.8	31.8	34.8
2	28.6	28.9	32.0	28.9	33.1	33.5	33.2	27.5
3	35.4	28.9	38.9	32.8	36.1	33.9	35.8	33.7
4	36.3	33.1	40.1	32.1	36.4	35.6	37.5	24.8
*5	36.9	27.3	34.3	41.7			41.1	37.5
Average	33.6	30.0	36.6	31.9	35.6	34.7	34.6	30.2
% change			+ 8.93	+6.33	+ 5.95	+15.67	+ 2.98	+ .67
IA								
Filling 1	23.5	22.9	24.8	23.9	24.1	23.3	23.6	22.2
2	17.9	17.6	18.0	17.9	18.4	18.8	18.5	18.7
3	21.8	21.6	23.7	18.6	22.6	19.5	22.1	19.3
4	23.1	18.8	21.6	19.1	22.5	19.2	22.3	20.4
*5	23.2	22.6	24.8	21.4			24.1	20.9
Average	21.6	20.2	22.0	19.9	21.9	20.2	21.6	20.2
% change			+ 1.85	-1.49	+ 1.39	--	--	--
After Dry Cleanings								
IA								
Warp 1	33.9	29.1	34.1	30.5	34.6	30.1	35.5	30.7
2	28.6	28.9	29.3	25.0	29.4	28.8	33.5	29.0
3	35.4	28.9	38.9	29.0	38.4	29.1	36.9	31.4
4	36.3	33.1	35.6	30.6	37.3	31.6	37.1	34.0
*5	36.9	27.3	30.9	24.7			38.3	23.3
Average	33.6	30.0	34.5	28.8	34.9	29.9	35.8	31.3
% change			+ 2.68	-4.00	+ 3.87	- .33	+ 6.55	+ 4.33
IA								
Filling 1	23.5	22.9	26.0	23.3	24.3	21.5	25.3	22.3
2	17.9	17.6	20.6	18.2	19.0	18.2	19.4	17.8
3	21.8	21.6	24.2	19.9	23.5	17.5	22.5	18.9
4	23.1	18.8	24.2	19.6	23.5	18.6	24.0	22.5
*5	23.2	22.6	25.9	20.0			25.5	19.2
Average	21.6	20.2	23.8	20.2	22.6	19.0	22.8	20.4
% change			+10.19	--	+ 4.63	- 5.94	+ 5.56	+ .99

*IA_5 not included in Average or % change
Each is an average of 6 computations

TABLE XXIII
ELONGATION

		Original Wet	Original Dry	After 5 Wet	After 5 Dry	After 10 Wet	After 10 Dry	After 20 Wet	After 20 Dry
After Launderings									
IIA Warp	1	26.8	18.7	21.6	16.9	23.2	18.8	24.6	18.9
	2	25.6	18.7	22.8	19.6	22.2	18.2	22.7	20.8
	3	23.9	17.8	23.5	19.8	22.9	19.5	24.2	19.6
	4	22.3	17.6	23.0	18.6	23.6	21.4	24.8	20.1
Average		24.6	18.2	22.7	18.7	23.0	19.5	24.1	19.8
% change				- 7.72	+ 2.75	-6.50	+ 7.14	- 2.03	+ 8.79
IIA Filling	1	23.1	18.2	21.8	19.0	22.4	19.9	21.3	20.0
	2	22.8	18.7	20.6	18.9	19.4	16.8	20.1	17.8
	3	22.3	18.2	20.6	20.5	20.3	17.4	21.8	18.9
	4	20.6	16.9	18.5	17.3	18.5	16.0	19.0	18.4
Average		22.2	18.0	20.4	18.9	20.2	17.5	20.6	18.8
% change				- 8.11	+5.00	- 9.01	- 2.78	- 7.21	+ 4.44
After Dry Cleanings									
IIA Warp	1	26.8	18.7	23.7	17.2	26.3	15.8	24.3	18.0
	2	25.6	18.7	22.7	19.0	22.3	16.9	22.8	18.3
	3	23.9	17.8	22.6	16.0	22.2	16.6	22.3	18.0
	4	22.3	17.6	23.8	17.9	22.2	17.9	22.8	17.6
Average		24.6	18.2	23.2	17.5	23.2	16.8	23.0	18.0
% change				- 5.69	- 3.85	-5.69	- 7.69	- 6.50	- 1.10
IIA Filling	1	23.1	18.2	21.8	19.0	22.4	19.9	21.3	20.0
	2	22.8	18.7	20.6	18.9	19.4	16.8	20.1	17.8
	3	22.3	18.2	20.6	20.5	20.3	17.4	21.8	18.9
	4	20.6	16.9	18.5	17.3	18.5	16.0	19.0	18.4
Average		22.2	18.0	20.4	18.9	20.2	17.5	20.6	18.8
% change				- 8.11	-5.00	- 9.01	- 2.78	- 7.21	- 4.44

Each is an average of 6 computations

TABLE XXIV

RESISTANCE TO ABRASION

	Original		After Launderings: After 5		After 10		After 20		After Dry Cleanings: After 5		After 10		After 20	
	*F. S. of W.	Hole	*F. S. of W.	Hole	*F. S. of W.	Hole	*F. S. of W.	Hole	*F. S. of W.	Hole	*F. S. of W.	Hole	*F. S. of W.	Hole
IA														
1	169	378	276	510	344	735	417	924	133	580	328	794	364	824
2	175	519	238	542	469	858	451	904	392	751	269	707	410	829
3	226	493	264	583	487	888	567	983	504	801	440	755	376	874
4	193	532	386	830	535	969	579	991	496	771	351	778	475	829
**5	215	444	461	899			508	988	217	472			374	730
Average	191	480	291	616	459	862	504	950	381	726	347	758	406	839
Difference			+100	+136	+268	+382	+313	+470	+190	+246	+156	+278	+215	+359
% change			+ 52.4	+ 28.3	+140.3	+ 79.6	+163.9	+ 97.9	+ 99.5	+ 51.2	+ 81.7	+ 57.9	+112.6	+ 74.8
IIA														
1	141	366	288	647	266	672	214	653	415	602	355	630	284	656
2	308	454	393	608	394	648	362	659	566	718	393	651	475	676
3	198	331	408	653	466	689	334	653	405	608	329	488	380	631
4	304	345	284	515	240	510	226	484	268	558	206	571	266	637
Average	238	374	343	606	342	630	284	612	414	622	321	585	351	650
Difference			+105	+232	+104	+256	+ 46	+238	+176	+248	+ 83	+211	+113	+276
% change			+ 44.1	+ 62.0	+ 43.7	+ 68.4	+ 19.3	+ 63.6	+ 73.9	+ 66.3	+ 34.9	+ 56.4	+ 47.5	+ 73.8

*First Sign of Wear
**IA_5 not included in calculations

TABLE XXV
COLORFASTNESS TO LIGHT*

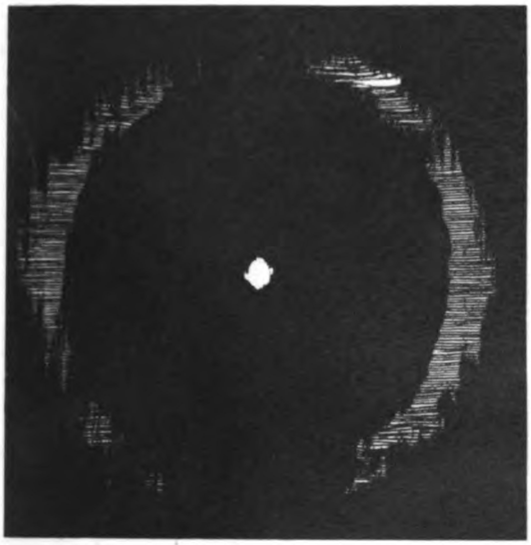
Fabric	Original	5 Launderings	10 Launderings	20 Launderings	5 Cleanings	10 Cleanings	20 Cleanings
IA_1	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0
IA_2	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0
IA_3	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0
IA_4	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0	CLASS 0
IIA_1	CLASS 2	CLASS 3	CLASS 3	CLASS 3	CLASS 3	CLASS 3	CLASS 2
IIA_2	CLASS 3	CLASS 3	CLASS 3	CLASS 3	CLASS 3	CLASS 2	CLASS 1
IIA_3	CLASS 3	CLASS 3	CLASS 3	CLASS 3	CLASS 3	CLASS 3	CLASS 2
IIA_4	CLASS 4	CLASS 4	CLASS 4	CLASS 4	CLASS 4	CLASS 4	CLASS 4

CLASS 0 - change after 10 hours exposure
CLASS 1 - no change after 10 hours exposure
CLASS 2 - no change after 20 hours exposure
CLASS 3 - no change after 40 hours exposure
CLASS 4 - no change after 80 hours exposure

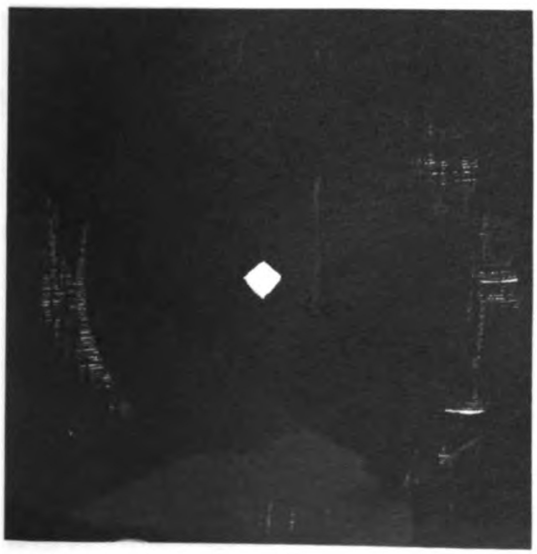
* Commercial Standard CS59-44, Textiles--Testing and Reporting, pp. 21-23

Plate XXXI
Resistance to Abrasion

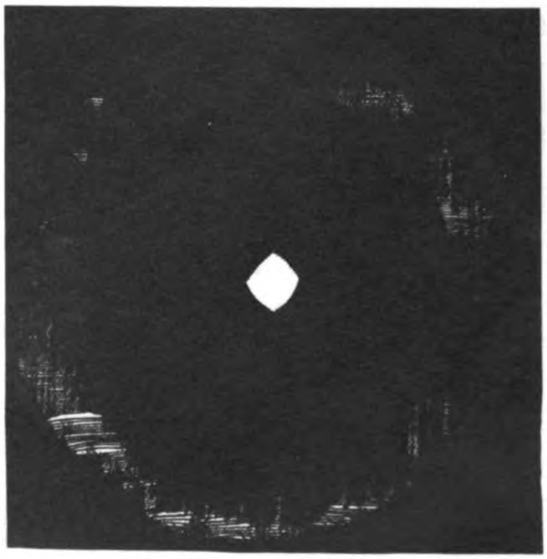
IA_4 - ORIGINAL
F.S. OF WEAR - 160
HOLE - 567



IA_4 - L5
F.S. OF WEAR - 415
HOLE - 820



IA_4 - L10
F.S. OF WEAR - 473
HOLE - 969



IA_4 - L20
F.S. OF WEAR - 753
HOLE - 1190

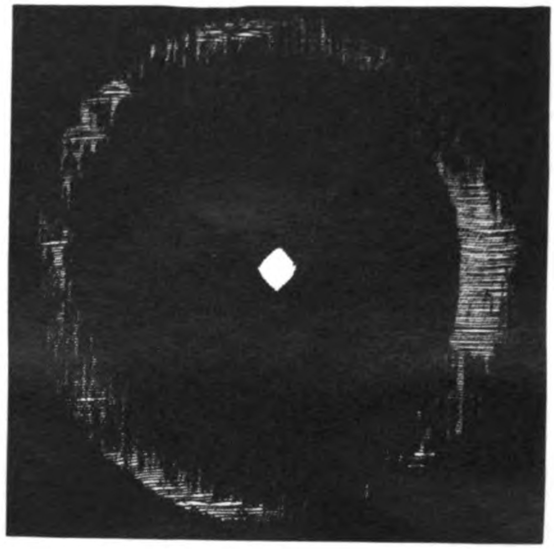
F.S. OF WEAR = FIRST SIGN OF WEAR

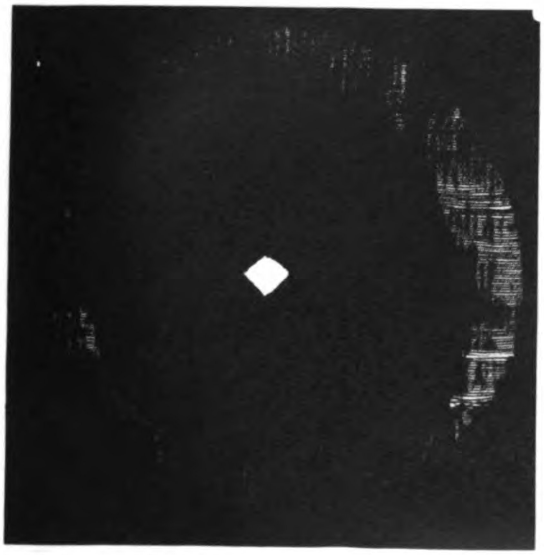
Plate XXXII

Resistance to Abrasion

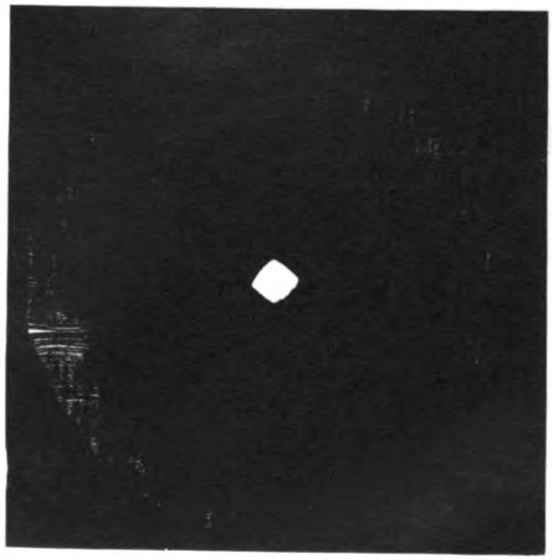
IA_4 - ORIGINAL
F.S. OF WEAR - 160
HOLE - 567

IA_4 - D5
F.S. OF WEAR - 458
HOLE - 854





IA_4 - D10
F.S. OF WEAR - 351
HOLE - 762

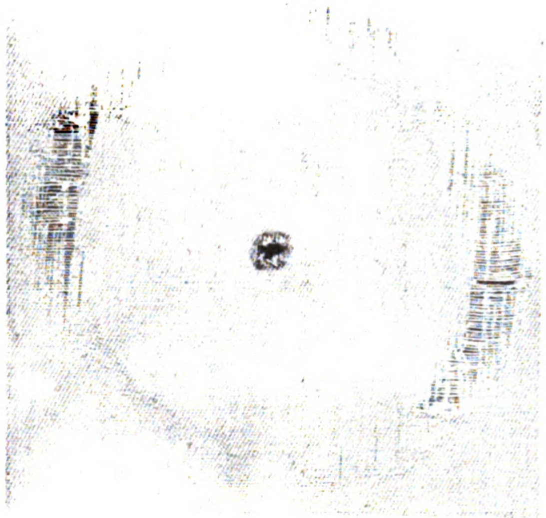


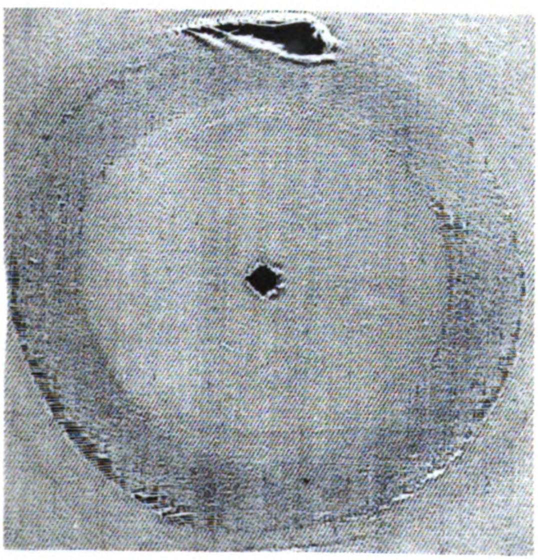
IA_4 - D20
F.S. OF WEAR - 477
HOLE - 838

F.S. OF WEAR = FIRST SIGN OF WEAR

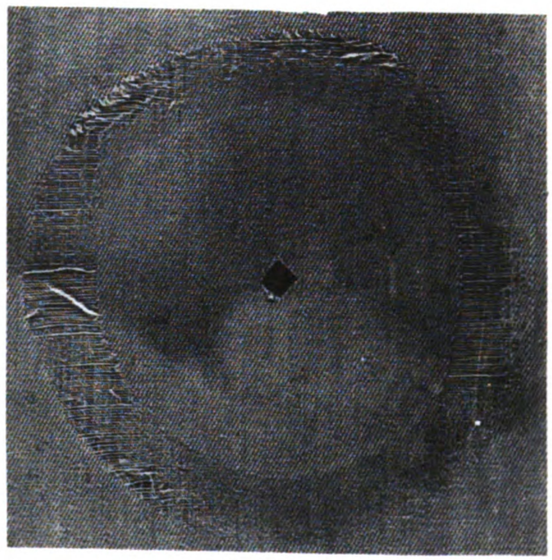
Plate XXXIII
Resistance to Abrasion

IA, - ORIGINAL
F.S. OF WEAR-173
HOLE - 426





IA, - L10
F.S. OF WEAR-426
HOLE-735

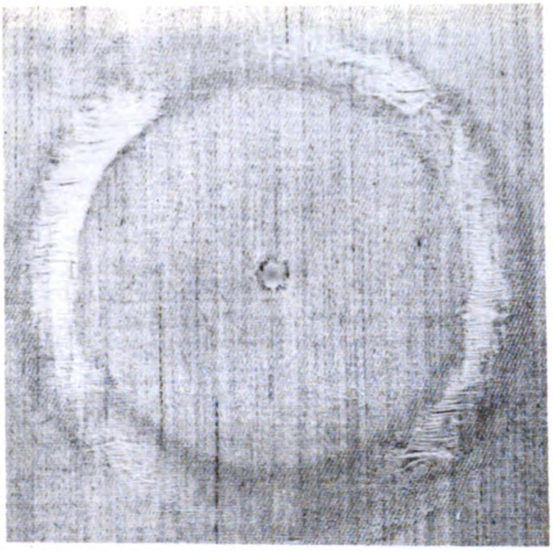


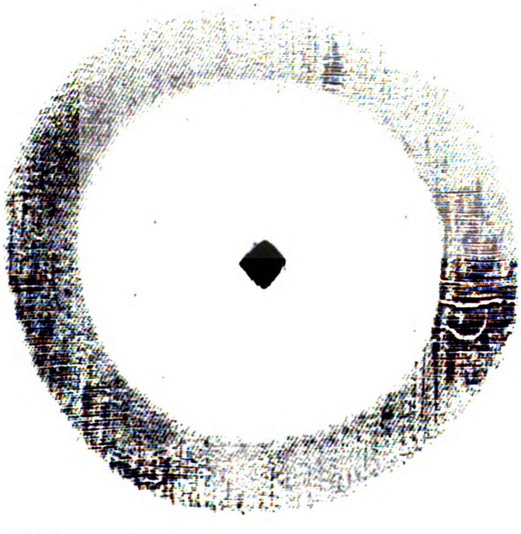
IA, - D10
F.S. OF WEAR-260
HOLE- 781

F.S. OF WEAR = FIRST SIGN OF WEAR

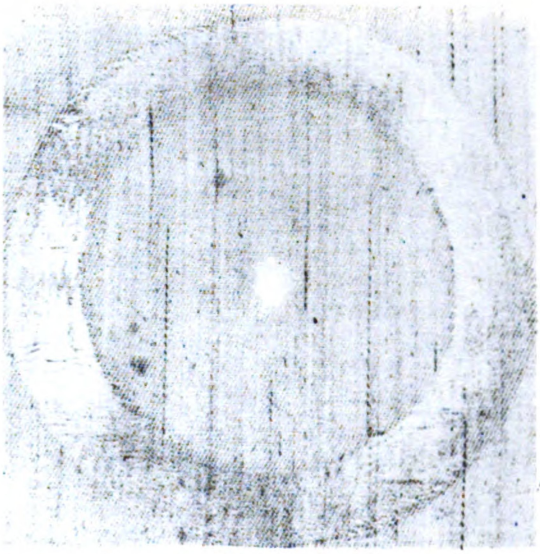
Plate XXXIV
Resistance to Abrasion

IA5 - ORIGINAL
F.S. OF WEAR - 201
HOLE - 451





IA5 - L20
F.S. OF WEAR - 478
HOLE - 1009



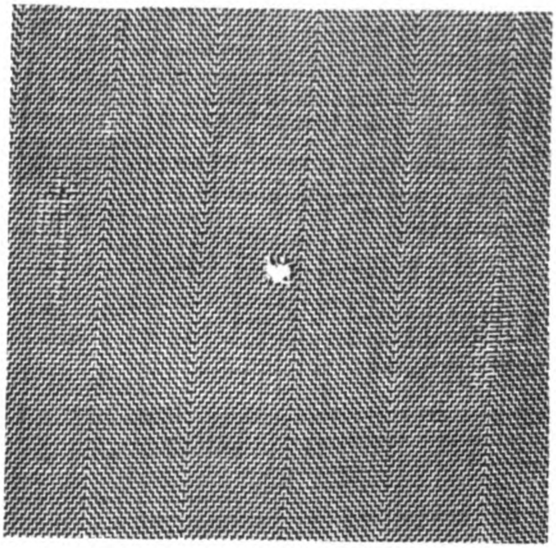
IA5 - D20
F.S. OF WEAR - 351
HOLE - 722

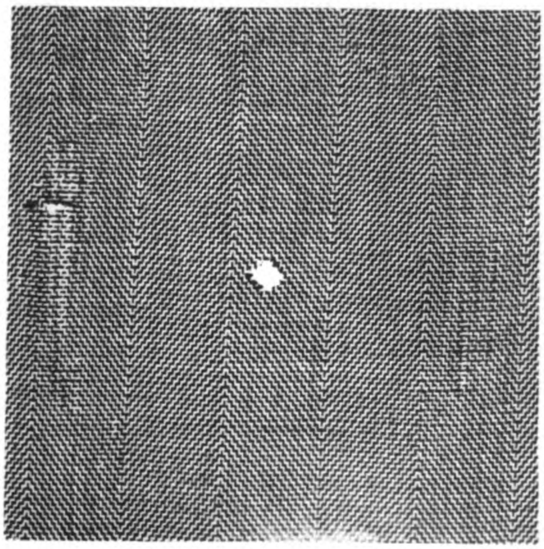
F.S. OF WEAR = FIRST SIGN OF WEAR

Plate XXXV

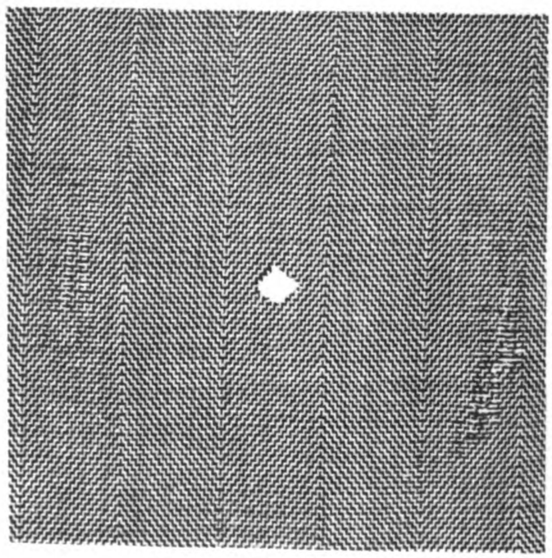
Resistance to Abrasion

IIA$_3$ - ORIGINAL
F.S. OF WEAR-154
HOLE - 351





IIA$_3$ - L 5
F.S. OF WEAR- 425
HOLE -676

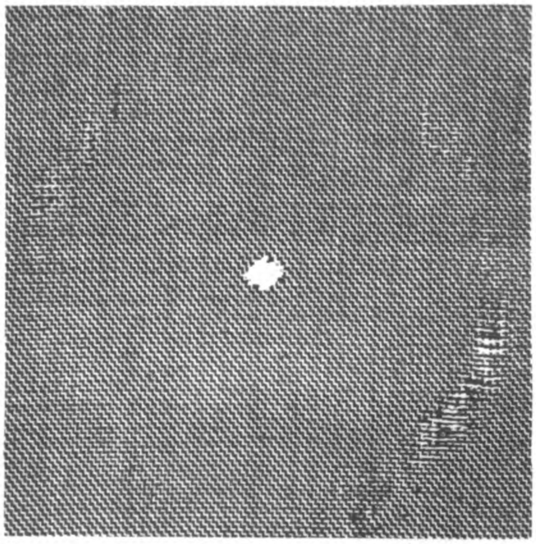


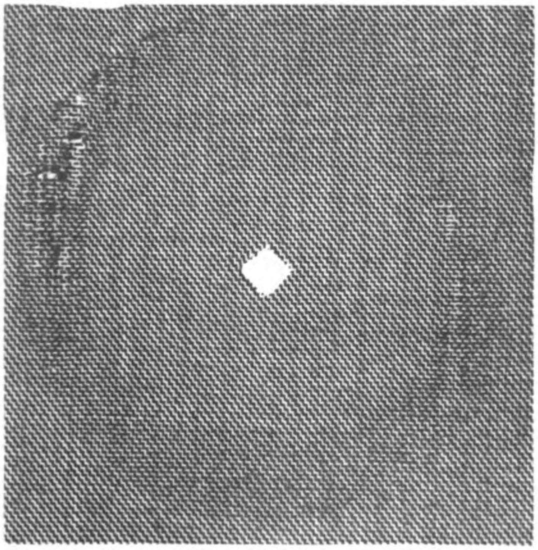
IIA$_3$ - D5
F.S. OF WEAR- 311
HOLE - 609

F.S. OF WEAR = FIRST SIGN OF WEAR

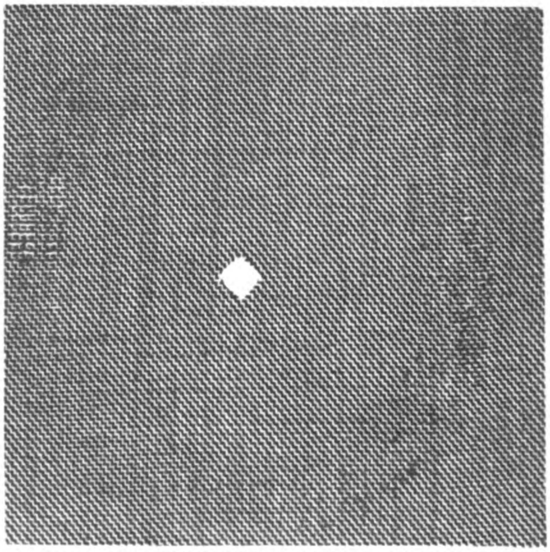
Plate XXXVI
Resistance to
Abrasion

IIA$_2$ - ORIGINAL
F.S. OF WEAR - 297
HOLE - 451





IIA$_2$ - L 20
F.S. OF WEAR - 351
HOLE - 676



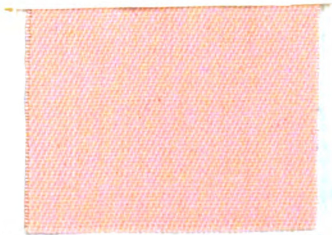
IIA$_2$ - D20
F.S. OF WEAR - 476
HOLE - 677

F.S. OF WEAR = FIRST SIGN OF WEAR

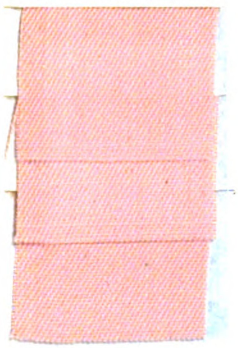
GROUP I - DRESS WEIGHT GABARDINES

IA_1

Original



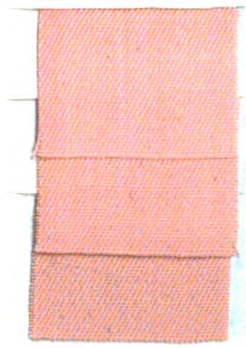
After Launderings | After Dry Cleanings



5

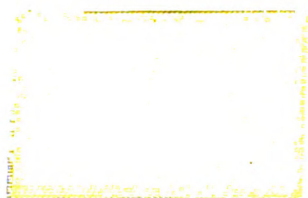
10

20



IA_2

Original

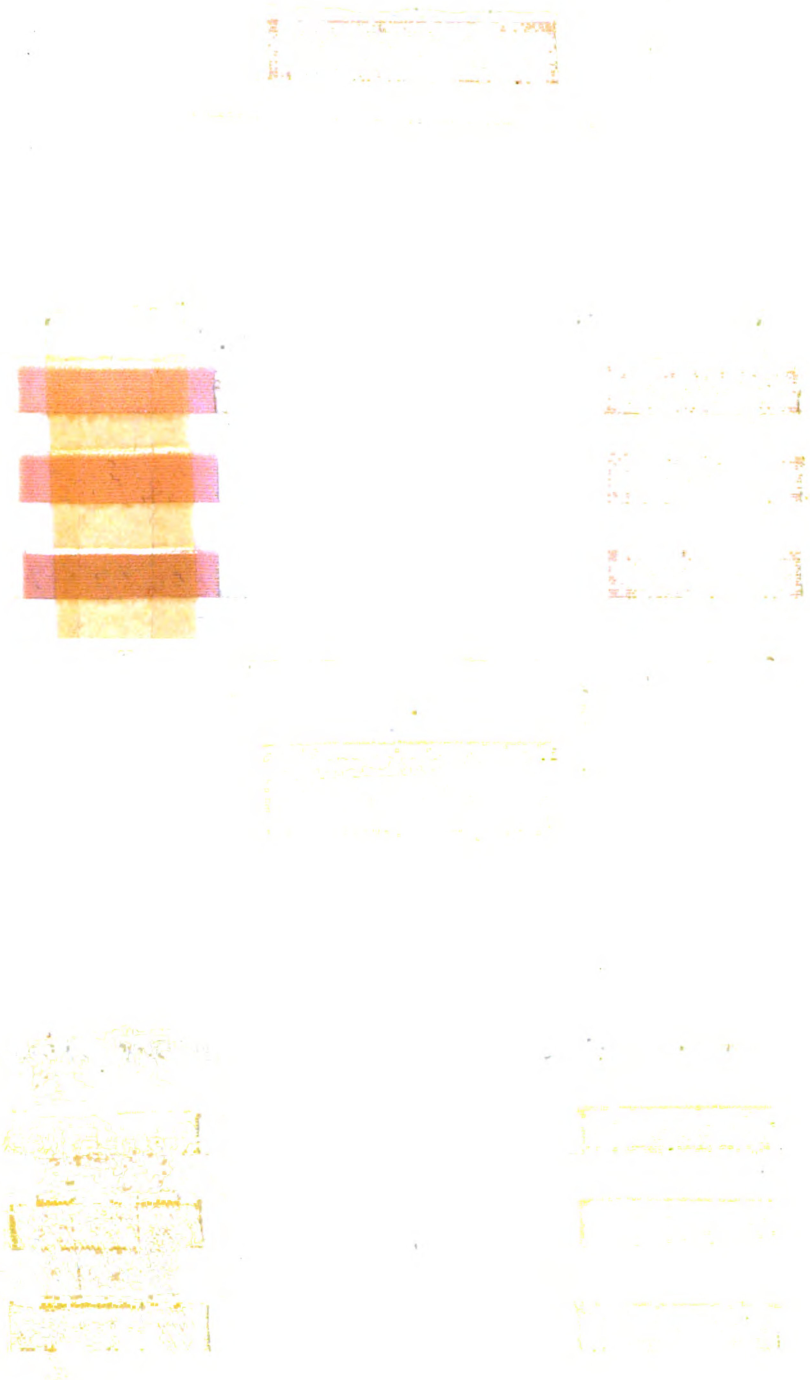


After Launderings | After Dry Cleanings

5

10

20



GROUP I - DRESS WEIGHT GABARDINES

IA_3

Original

After Launderings | After Dry Cleanings

5

10

20

IA_4

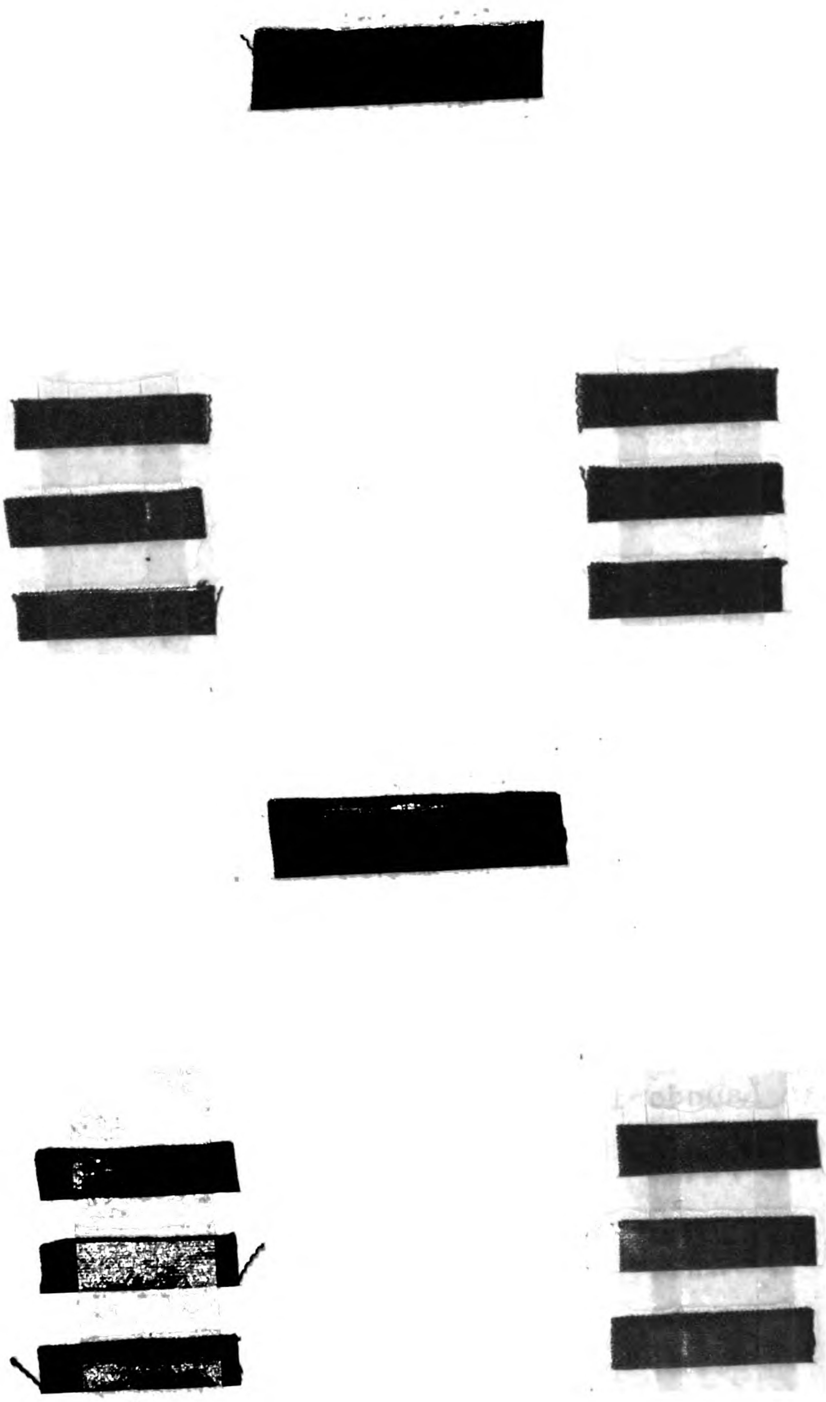
Original

After Launderings | After Dry Cleanings

5

10

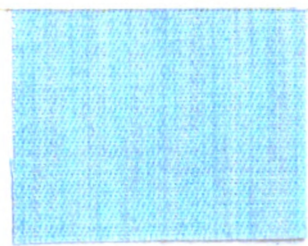
20



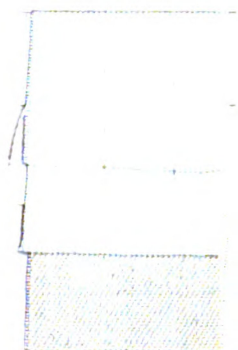
GROUP I - DRESS WEIGHT GABARDINES

IA_5

Original



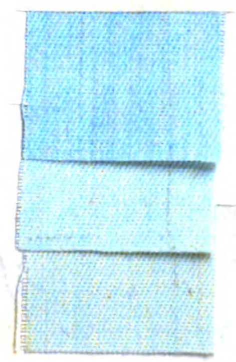
After Launderings After Dry Cleanings



5

10

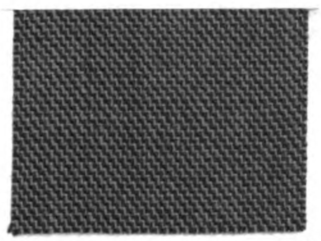
20



GROUP II - SUITINGS

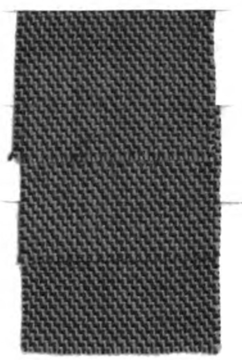
IIA_1

Original



After Launderings

After Dry Cleanings



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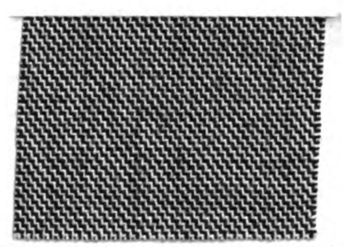
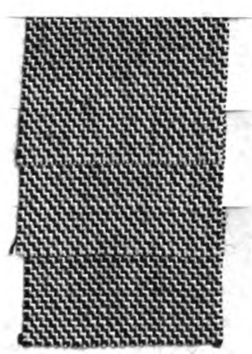
IIA_2

Original



After Launderings

After Dry Cleanings



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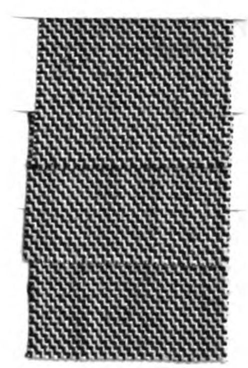

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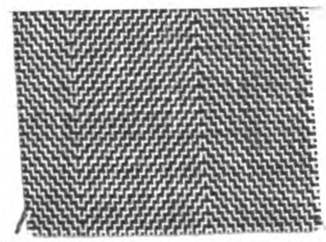
GROUP II - SUITINGS

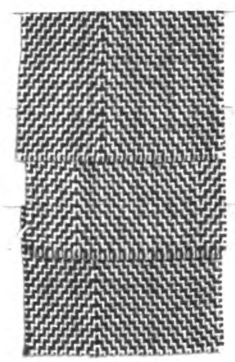
IIA_3

Original



After Launderings

After Dry Cleanings



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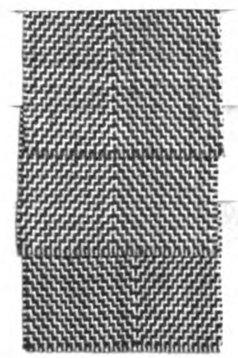
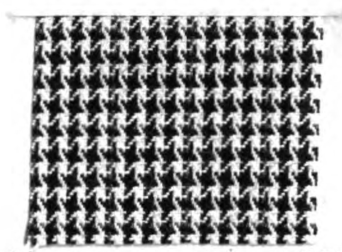


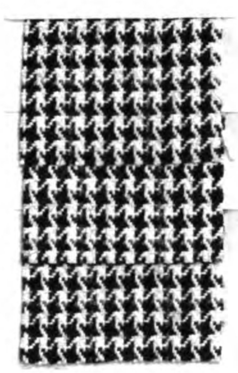
IIA_4

Original



After Launderings

After Dry Cleanings



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