TECHNICAL REPORT
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COMPARATIVE STUDY OF PICKER AND DRAW-FRAME BLENDS OF COTTON AND NYLON

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UNITED STATES ARMY
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Natick, Massachusetts 01760

U.S. ARMY MATERIEL COMMAND

Clothing and Organic Materials Division
TS-143

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FOREWORD

The increasing use of synthetic fibers in combination with natural fibers in military fabrics has necessitated a careful appraisal of the role of fiber distribution on the functional properties of blended fabrics. Military considerations such as comfort under conditions of severe environmental stress, and protection against thermal radiation from nuclear weapons depend in part upon the relative position of the component fibers in the yarn structure. In addition the relative cost and efficiency of producing blended yarns are important economic considerations in deciding at what stages of manufacturing to initiate the blending operation.

The project described in this report was planned in an effort to derive some information on the fundamentals of blend distribution in yarns made of high-modulus nylon and cotton. Detailed microscopic examinations were made to evaluate longitudinal, radial, and rotational distribution in a series of blended yarns in which blending was accomplished at two stages of processing. The findings of this investigation have significantly enlarged our area of knowledge regarding these blend combinations.

The study was carried out under the supervision of Mr. Louis I. Weiner of the Army Natick Laboratories by Messrs. Shyamkant D. Shahane and Virendra Singh as a thesis project at the Lowell Technological Institute in Lowell, Mass. We are deeply indebted to the staff and faculty of Lowell Tech. for providing the facilities for this study. We wish to specially acknowledge the assistance and suggestions provided by Professors John A. Goodwin, Fritz F. Kobayashi, David H. Pfister, and Clarence J. Pope.

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ABSTRACT

Blended yarns were produced from a good grade of cotton (1½-inch American-Egyptian) and nylon 420 (1½ inch - 2.3 denier) with percentages of nylon of 0, 25, 50, 75, and 100. Blending was done at the picker and at the drawframe for each blend composition. All yarns were spun to a nominal 28^s count (cotton system) with a twist-multiplier of 3.0. Cross-sections of these yarns were examined microscopically to determine the longitudinal, radial, and rotational distributions of the fibers.

It was observed that the yarns produced by picker blending were more uniform in composition than those produced by draw-frame blending. However, the draw-frame blends conformed more closely to the planned nominal composition of the yarns. In the picker blends the variation in blend composition was almost the same in sections taken one fiber length apart (1½") or taken randomly at any length greater than 7½". But, in the draw-frame blends the former (short length variation) was less than the latter (long length variation). However, in neither the picker nor in the draw-frame blends was "adjacency" correlation noted; i.e., adjacent sections were no more uniform in composition than sections 2, 3, or 4 fiber lengths removed.

The radial distribution analyses indicated that for both the picker and draw-frame blends there was in most instances a deficiency of nylon at the periphery and at the center of the yarns. However, away from the center and periphery the blend composition closely matched the average blend composition of the yarns. The rotational distribution analyses showed that sectors having a high nylon concentration were found to be flanked by sectors of slightly more than average nylon concentration, for the yarns examined.

COMPARATIVE STUDY OF PICKER AND DRAW-FRAME BLENDS OF COTTON AND NYLON

I. Introduction

The increasing use of man-made fibers in blends has brought to light many complex problems in processing and in end-use which had not been anticipated based upon experience with natural fibers. In one sense, the use of man-made fibers should simplify processing and probably facilitate achieving desired functional characteristics because of their predictable uniformity. The staple length, diameter, and strength of man-made fibers can be controlled within narrow limits, whereas in the case of natural fibers both average values as well as variation within lots will depend upon imperfectly controlled conditions of origin, weather, maturity, disease, collection, and fiber preparatory processes. However, when man-made fibers of predictable uniformity are combined with natural fibers of unpredictable non-uniformity, the differences between the man-made and natural fibers are superimposed upon the existing non-uniformity of the natural fibers.

Most textile processing equipment in use today was developed over a period of many, many decades by an essentially trial and error process to adapt it to the properties and processing characteristics of natural fibers. The range and character of machine adjustments employed for natural fibers permit the attainment of relatively high levels of processing efficiency. Attempts to process man-made fibers and blends have required major changes in the possible range of adjustments and also significant changes in the character of the processing equipment itself. These changes, small and large, take into consideration differences in processibility arising from fiber dimensions, mechanical properties, bulking of the fibrous mass, and static potential.

When one examines blending from the standpoint of end-use performance, both functional and aesthetic properties are found to depend not only upon the character of the fibers composing the blend, but also upon the distribution of the blended fibers in terms of both location and quantity. The great impetus given to the development of blends has its origins in the possibility of optimizing the performance of fabrics by using fibers having properties in combination which could not be achieved by using either fiber by itself. Blends of the polyesters with cotton have already become a significant element in the textile economy because of their exceptional aesthetic properties. Blends of nylon with cotton are assuming greater importance in the field of functional clothing where improvement in durability and protective features are sought.

In manufacturing blends using the cotton system, an important choice which must be made, is whether to blend at the picker or at the draw frame. Normally, it is expected that a picker blend would be more homogeneous. However, for some applications, a certain lack of homogeneity in blend distribution may be considered advantageous. Of course, economic factors have a major influence on the decision as to whether to blend at the picker or the draw frame. The major purpose of this study was to make a comparative analysis of picker versus draw frame blending systems of producing nylon-cotton yarns in terms of the resulting distribution of the component fibers. The basis for characterizing the distributions was the longitudinal, radial, and rotational parameters used by Coplan and Bloch (1). The manufacturing techniques employed were designed to simulate, to the greatest extent possible, the procedures that are normally used in blend production. The range of variables was selected to be practical both from the standpoint of conventional yarn constructions, and to facilitate the detailed microscopic analysis.

The available literature on the subject of blending may be divided into three categories: (1) processing techniques which may embrace manufacturing as well as dyeing and finishing; (2) the evaluation of the nature of the distribution of the component fibers in the textile structure; and (3) the changes in functional properties resulting from blending and from changes in blend composition or blending techniques. The bulk of the literature consists of papers in category (3). Since this study is concerned with the manufacture of blended yarns and the determination of the distribution of the fibers in the yarns, reference will be made to the first two categories only.

Probably the most complete as well as the most pertinent information on techniques for manufacturing blended yarns is that published by fiber producers such as DuPont (2) and Chemstrand (3). For example, DuPont Bulletin No. N-163, dated October 1963 (2), describes the methods of processing blends of cotton and 420 nylon utilizing conventional cotton manufacturing equipment. This bulletin provides details on sequence of operations, settings of the various types of equipment, specific instructions for picking, carding, drawing and spinning, and, of great importance, hints for avoiding processing problems such as lap splitting, web dragging, and ends down in spinning. DeBarr and Walker (4) made a comprehensive study of the influence of manufacturing parameters on the properties of blended yarns and fabrics. They stressed the basic significance of fiber properties, the number of doublings, and the amount of drafting on fiber arrangement. In addition they were able to show a relationship between short and long term variations in blend composition on the appearance and physical properties of the resultant cloth. Lund (5) found that the coefficient of variation of weight per unit length of the yarn was a function of the coefficient of variation of fiber weight per unit length and of the average number of fibers in a cross section of yarn. He also reported that a random arrangement of fibers should be obtained when the number of doublings after blending exceeds the number of fibers in the cross-section of the yarn. Goodwin (6), reporting on work by Nair, mentions processing problems encountered in the manufacture of orlon-cotton blended yarns such as lap-splitting, web sagging, and static.

The most comprehensive work on determining actual blend composition using microscopic techniques was done by Coplan and Bloch (1) and Coplan and Klein (7). Although other techniques such as chemical separation and density gradient differences may be used for analyzing blends, only the microscopic procedure can provide information on the actual location of individual fibers in the blended yarn. Coplan and Bloch studied wool-nylon and wool-viscose yarns manufactured on the woolen system. Since the analysis of the nylon-cotton blended yarns reported in this study parallels that of Coplan and Bloch, their findings on the wool blends are quoted here for reference purposes.

<u>Longitudinal Distribution</u>

(1) On the average, maximum deviation in blend composition of some woolen type wool-nylon and wool-viscose yarns occurs at distances along the yarn as short as one fiber length apart.

(2) The deviation in blend composition between sections one fiber length apart is only occasionally larger than that found by comparing random pairs of sections.

(3) An Index of Blend Irregularity indicates that for all the yarns examined the degree of mixing is poorer than could be expected for the ideal random yarn.

(4) The course of the non-ideal randomness of blend is here ascribed to incomplete separation of the original fiber stocks into single fiber elements.

(5) The blend concentration at a given section is uncorrelated with the total number of fibers found at that section.

(6) There is no notable effect of average yarn twist on any of the blend characteristics just noted.

Radial Distribution

(1) There is a general tendency for the peripheral regions of all yarns examined to have more wool than the nominal average blend.

(2) The effect of average yarn twist on radial distribution patterns is nil for the nylon blends and not great for the viscose yarns.

(3) The radial blend distribution pattern seems to be uncorrelated with the total weight of fibers at the section in question.

Rotational Distribution

(1) Adjacent rotational regions within given cross sections are, on the average, more like each other than are remote regions.

(2) The pattern of rotational distribution seems to be nearly random except for the residual effect of clustering noted for the longitudinal direction.

(3) It is therefore concluded that merely twisting an already established aggregation of fibers does not particularly disturb their relative positions as measured rotationally.

Ford (8) found in blends of Fibro and other man-made fibers, spun on the cotton system, that as the denier of one component is increased, that component is found to an increasing extent in the surface layers of the yarn. DeBarr and Walker (4) confirmed Ford's findings with respect to fiber denier and also reported that the longer fibers preferentially spin to the surface of the yarn.

II. Experimental Procedure

A. Manufacturing Process

The manufacture of nylon/cotton blended yarns on cotton machinery requires certain specialized procedures which take into consideration the differences in physical and mechanical properties of the two component fibers as well as the differences in bulk properties of the mixtures. In the present work, in which blending was done at the picker or at the draw-frame, adjustments were required to facilitate the handling of 100% nylon and the three blend compositions on cotton processing equipment. Fortunately, by changing a few machine settings and speeds and making a few mechanical improvisations it was possible to produce rovings from which good quality yarn could be spun.

Blending

Blending for the picker blends was accomplished by spreading out weighed lots of cotton and nylon in layers to form sandwich mixes. These lots consisted of 25% nylon and 75% cotton; 50% nylon and 50% cotton; and 75% nylon and 25% cotton. The total weight of each lot was 40 pounds.

Picking

Previously weighed 100% cotton and 100% nylon lots, as well as the above-mentioned three lots, were processed separately through the picking equipment (see Appendix A). The picker was thoroughly cleaned before each lot was processed and was adjusted to produce a lap weighing approximately thirteen ounces per yard (40-inch width).

As the percentage of nylon in the blend was increased, the pressure on the calender rolls was increased and that on the lap pin was reduced. The air pressure on the lap pin was reduced from 32 pounds per square inch to 12 pounds per square inch for lots containing 50% nylon and above. With percentages of nylon 50% and above, the use of a top split lap preventer and a cardboard sleeve on the lap pin was found to be necessary. For 75 and 100% nylon the two-bladed beater was eliminated and the Kirschner beater was used. In addition, the plate setting in the blending reserve was increased from 9¼-inches to 11 inches. This was done to bring the lap weight up to the required 13 ounces per yard.

A relative humidity of 50% with a temperature of 70°F was found to be satisfactory for the picking operation.

Carding

For the 100% cotton, carding was done on a Saco Lowell card. Regular cotton settings and speeds were used (see Appendix B). All other lots were processed separately on an H & B card equipped with a fancy roll. The settings and processing particulars recommended in DuPont bulletin N-163 were used (see Appendix C). With the nylon blend it was essential to use a web supporting plate at the delivery end of the card. All of the lots carded satisfactorily at a relative humidity of 50% and temperature of 80°F. The weight of the slivers produced was 50 grains per yard.

Drawing

The draw-frame used was a four delivery single head Saco Lowell model equipped with common rolls (for settings see Appendix D). The picker blend lots were passed through the drawing operation twice (see Appendix G). For the control yarns, the 100% nylon and 100% cotton card slivers were passed through two drawing processes (see Appendix G). For the draw-frame blends the remaining portions of the 100% cotton and 100% nylon card slivers were separately passed through a preliminary drawing operation. The three different blend percentages were achieved by feeding different numbers of these pre-drawn slivers of nylon and cotton to the draw-frame (see Appendix D). The three blended lots were then given a finisher drawing operation. After this "finisher" drawing operation the slivers of the three lots were reversed manually (see Appendix G). This sliver reversal was done to permit the trailing hooks as they came out of the card, to go into the spinning frame as trailing hooks.

On all of the drawing operations eight ends of sliver were fed. The sliver weight was maintained at 50 grains per yard for the preliminary blending and finishing drawings. All finisher slivers were tested for uniformity on a Saco Lowell evenness tester. Those tension gears that gave the most uniform slivers were employed for each lot.

Roving

A Saco Lowell Roving frame with a 3 over 3, single apron drafting system (FS-2) was used. Six bobbins of 3.0 hank roving were made from each lot. The 100% cotton lot was processed first. Then picker blend and draw-frame blends having the same percentage composition were processed followed by the 100% nylon lot.

Turns per inch in the roving were reduced with the increase in the percentage of nylon (see Appendix E). Cleaning of top rolls to remove the wax deposited by cotton was found necessary to prevent roller lapping. To check the twist of the roving, each lot was given a preliminary trial on the spinning frame to confirm the fact that it would draft and unwind satisfactorily.

Spinning

All eight lots were spun on a Fales and Jenks ring spinning frame to produce 28s nominal count yarn (cotton system), with a twist multiplier of 3.0, using double feed roving. All of the lots were spun at the same time to make three bobbins from each lot. Other particulars are given in Appendix F.

Production Organization

The organization of the processing details showing the weights and drafts at different stages of processing required to give the planned yarn size is shown in Appendix I.

B. Microscopic Analysis

The microscopic work may be broadly divided into two areas: preparation of yarn cross-sections and determination of the relative positions of fibers in these cross-sections.

Preparation of Yarn Cross Sections

The technique consisted of suspending yarns mounted on paper cut-outs in a resin monomer which was subsequently polymerized. The ingredients of the resin mix were 150 ml. of methyl methacrylate monomer (stabilized with 0.006% hydroquinone): 80 ml Santicizer M-1 (Monsanto plasticizer); and 0.25 gm. benzoyl peroxide initiator.

The stabilizer had to be removed from the monomer before polymerization. This was done by washing with one normal potassium hydroxide in a separatory funnel. Three or four such treatments were sufficient to remove the stabilizer. This was followed by two or three washes with water at room temperature. Residual moisture in the monomer was removed by filtering through dry filter paper.

The dimensions of the paper cut-outs and the method of mounting the yarn are shown in Figure 1. Six sections, each separated by one staple length ($1\frac{1}{2}$-inches) from the previous or succeeding section, were obtained. Each cut-out, with yarn in place, was inserted into the larger half of a gelatin veterinary capsule and the monomer mix consisting of monomer, stabilizer, and initiator was poured into the capsule. Care was taken to avoid the formation of air bubbles. The tops were placed on the capsules and sealed by tape. The capsules were then cured for twenty-four hours at 126°F in an oven. After curing, the gelatin was washed off by hot water. The polymer was then cut into two halves at the exact center of the cutout which had been premarked so that the mark was visible through the polymer mass. A small chip was then

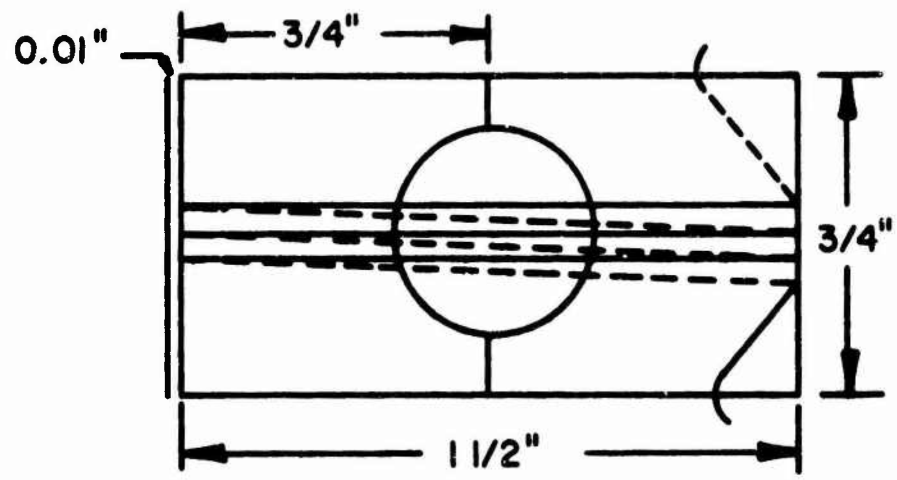


FIGURE 1. PAPER CUT OUT SHOWING YARN WRAPPING SYSTEM

cut from one of these two halves. The chip was embedded in paraffin and 40 micron sections were cut using a Bausch and Lomb rotary microtome. To emphasize the difference between the fibers, sections were dyed with a cotton dye at room temperature for two to three hours. The dye was then set by addition of sodium carbonate solution. After allowing about 15 minutes for setting of the dye the sections were washed in water. The dyeing and setting solutions were as follows:

1 gm. Procion blue dye in 50 cc. of water
(containing one drop of Triton X-100 wetting agent)

10 gms. sodium chloride

5 gms. sodium carbonate in 50 cc. of water

Microscopic Examination

The dyed sections were mounted in mineral oil and examined and traced by means of the Camera Lucida using a 10x ocular and 43x objective in an AO Spencer Microscope.

The longitudinal, radial, and rotational fiber distributions were obtained from the Camera Lucida tracings following the procedure of Coplan and Bloch (1) with some variations.

Since three bobbins of each of the six blended yarns had been prepared and only five embeddings were required for each yarn, two embeddings were made of yarn from each of two bobbins and one embedding of yarn from the third bobbin. The yarn from each bobbin was taken randomly. However, of the six sections that could be taken from each embedding only five consecutive sections were analyzed. Thus five cross-sections at $1\frac{1}{2}$-inch intervals were taken from five yarns chosen randomly, from each of six different blended yarns, giving a total of 150 sections.

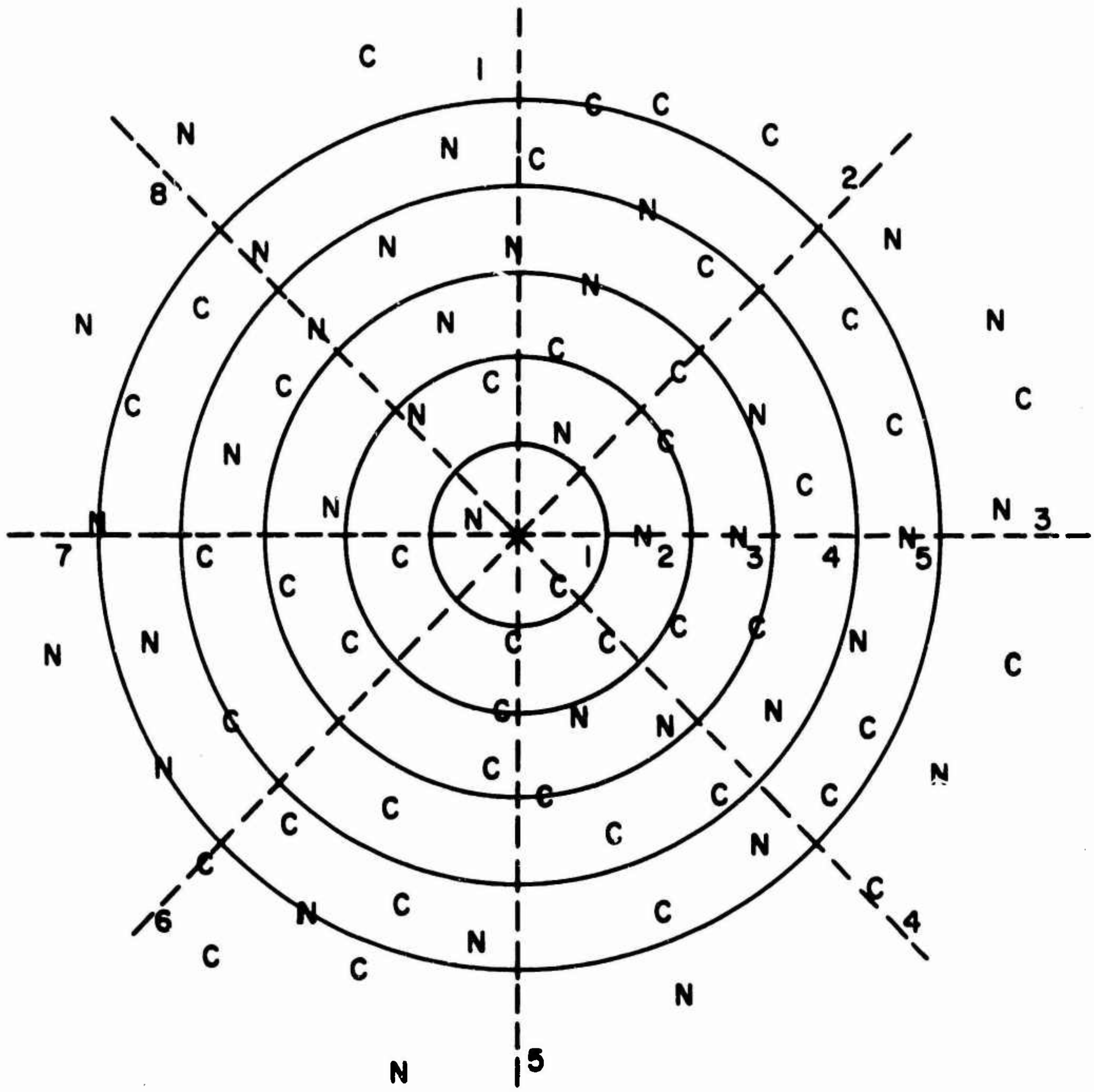
C. Description of Distributions Analyzed

Coplan and Bloch (1) obtained data in their study for three distributions designated as longitudinal, radial, and rotational. The longitudinal distribution consists of determining the total number of each type of fiber in each cross section, and expressing the number of one type of fiber as a percentage of the total number of fibers in that cross section, for each section analyzed. This distribution may also be expressed as a weight percentage by taking into consideration the denier of the fibers. Thus, for the longitudinal distribution it was possible to compute the percentage of nylon in each section, for the five sections taken consecutively at $1\frac{1}{2}$-inch intervals along the yarn; and to compare these percentages with those from the other groups of five sections taken at $1\frac{1}{2}$-inch intervals in the larger random selection of yarn from the three bobbins. Therefore, for each type of blended yarn a longitudinal distribution of the percentage of nylon fibers in twenty-five different sections could be obtained. The radial distribution provides an indication of the relative position of each type of fiber with respect to the center of the yarn as compared to the periphery. This concept is quite important in blended yarn usage where it is often desired to have one or another component spin to the outside of the yarn. A given cross-section of yarn can be divided into a number of concentric circles as shown in Figure 2. The circles may be of equal area or of equal diameter as spaced from the center of the yarn. By counting the number of fibers of each type in each ring formed by the circles and by comparing the number or percentage obtained with other rings it is possible to obtain the radial distribution of the fibers in the yarn. Analyses of this type, for a number of sections, can reveal if there is any preferred position for one of the two components in the section of the yarn. For this study, concentric circles spaced 1/2-inch apart were used for locating the position of the fibers in the Camera Lucida projections. Computation of radial distribution data for all of the fiber sections was accomplished on a GE 225 computer. The equation used and a sample computation are shown in Appendix J. Rotational distribution patterns were obtained by dividing the tracing of the yarn cross-section into eight "pie" shaped sectors, using four straight lines passing through the center of the section as shown in Figure 2. The center of the yarn has a descriptive meaning at any cross section. But the top of the yarn is an entirely arbitrary location for each section. However, once the top is selected, meaningful comparisons may be made among the various octants which thus provides considerable information for characterizing the nature of the fiber distribution. Photographs of sample cross-sections of each of the six blended yarns are shown in Appendices K, L, and M. The magnification used was about 190X.

III. Results and Discussion

A. Longitudinal Distribution Characteristics

Figure 3 illustrates the nature of the longitudinal distributions on a number average basis obtained for a picker blend (upper series of graphs designated as No. 2) and for a draw-frame blend (lower series of graphs designated as No. 5). While both of these blends had been designed to have 50% of nylon on a weight basis, the picker blend actually had a higher nylon concentration on a weight basis. On a fiber number average basis the picker blend



—— SOLID LINE CIRCLES USED FOR RADIAL DISTRIBUTION

---- DASHED LINES USED FOR ROTATIONAL DISTRIBUTION

(PIE SHAPED SECTOR HAVING HIGHEST NUMBER OF NYLON FIBERS "N" WAS DESIGNATED AS "I" OTHER SECTORS NUMBERED CLOCKWISE SEQUENTIALLY)

FIGURE 2, CAMERA LUCIDA TRACING SHOWING FIBER POSITIONS WITHIN INNER FIVE CIRCLES

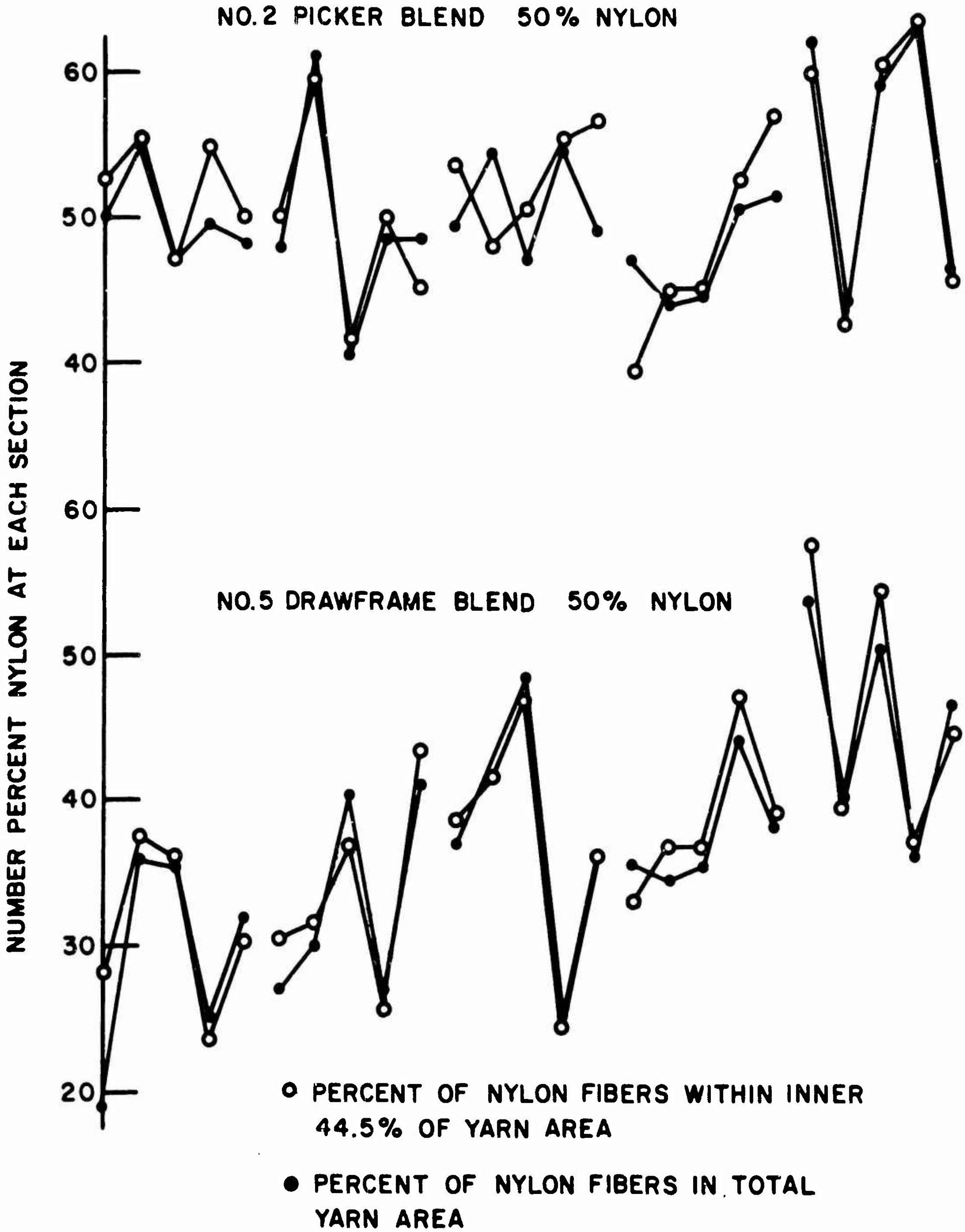


FIGURE 3, NYLON CONCENTRATION IN YARN SECTIONS was 50.4% nylon and the draw-frame blend was 37.0% nylon. On a weight average basis the picker blend was 61.0% nylon and the draw-frame blend was 47.6% nylon (see Table I). Thus, in comparing the graphs in Figure 3, the values for the picker blend (upper set of graphs) tend to distribute themselves around the 50.0% line, while the values for the draw-frame blend (lower set of graphs) distribute themselves around the 37.0% line. The five separate groups of "joined" lines going from left to right in Figure 3 represent the five randomly selected yarns from three bobbins. Each group of "joined" lines represents the individual sections taken at $1\frac{1}{2}$-inch intervals from one random sample. To provide some indication of the gross radial distribution of the fibers in each section, the open circles plotted for each value in Figure 3 represent the number percent of nylon fibers within the inner 44.5% of the yarn area (see section III (B)), whereas the points plotted for each value represent the number percent of nylon fibers for the total yarn area of each section. The figure of 44.5% was derived from the solution of the equation

$$100 \times \frac{\text{Area within 6th circle from center of Camera Lucida tracing}}{\text{Area within 9th circle from center of Camera Lucida tracing}}$$

Considerable information concerning the longitudinal distribution of the fibers in the yarns may be derived from an examination of Figure 3. For example, extreme variations in blend distribution occurred both within and between the $7\frac{1}{2}$-inch ($5 \times 1\frac{1}{2}$-inch) lengths of yarn which were sectioned. For the picker blend the variations within the $7\frac{1}{2}$-inch sections were almost equal to the variations among the $7\frac{1}{2}$-inch sections, when individual sections are compared. Using the same basis of comparison for the draw-frame blends more variation was noted among the $7\frac{1}{2}$-inch sections than within. Even though the within $7\frac{1}{2}$-inch section variation for the drawframe blend appears to be as great as the within $7\frac{1}{2}$-inch section variation for the picker blend, the overall or among $7\frac{1}{2}$-inch section variation of the draw-frame blend is much greater than that of the picker blend. Therefore, the picker blend leads to a much more uniform yarn with respect to blend distribution. This point becomes obvious when the variations of the individual plotted points for the picker blend are compared with the variations of the individual plotted points for the draw-frame blend. Discussed later in the report is the "index of blend irregularity" which further confirms the greater uniformity of the picker blend.

Another interesting observation for both the picker and draw-frame blended yarns is that, for the great majority of individual sections, the plotted points for the inner 44.5% of the yarn practically coincide with points for the total area of the yarn.

TABLE I

COMPOSITION OF BLENDED YARNS

I.D. No.	Type of Blend	Nominal Percent Nylon	Nominal Percent Cotton	Actual Percent By Weight Nylon	Actual Percent By Weight Cotton	Actual Percent By Number Nylon	Actual Percent By Number Cotton
1	Picker Blend	25.0	75.0	18.0	82.0	12.5	87.5
2	Picker Blend	50.0	50.0	61.0	39.0	50.4	49.6
3	Picker Blend	75.0	25.0	70.0	30.0	60.0	40.0
4	Draw-frame Blend	25.0	75.0	26.4	73.6	19.0	81.0
5	Draw-frame Blend	50.0	50.0	47.6	52.4	37.0	63.0
6	Draw-frame Blend	75.0	25.0	72.5	27.5	63.0	37.0

Results of the chemical test on sliver and roving of nominal 50% nylon content--picker blend

	Actual Percent by weight Nylon	Actual Percent by weight Cotton
Sliver	58	42
Roving	62	38

Thus, if the diameter of the yarn is determined by the position of the outermost fiber in the yarn periphery, then the outermost portions of the yarn consist of a void interspersed with a few random fibers.

Adjacency Correlation for Longitudinal Distribution

In general, it might be expected that the distribution of fibers in sections of yarn close together would be more similar than the distribution of fibers in sections of yarn separated by longer distances. Gross examination of Figure 3 revealed that this is not the case. Coplan and Bloch (1) developed an interesting technique for characterizing the degree of so-called "adjacency correlation." This is done by plotting the average difference between the number of fibers per section versus the distance between sections. The average differences are computed for sections one, two, three, and four lengths (1½-inches) apart, and for a large number of random pairs of sections. If the differences in total number of fibers were smaller for sections close together, this would be considered to be positive correlation and correspond to curve 1 in Figure 4, taken from Coplan and Bloch (1) which is illustrative in natu only. If so-called "drafting waves" were present in the yar .t is likely that short-period high-amplitude fluctuations in yarn weight would occur, and sections close together would differ more in total number of fibers than sections farther removed. This would be considered to be negative correlation as corresponds to curve 2 in Figure 4. Finally, if sections close together did not differ in total number of fibers from sections not close together, then no adjacency correlation exists and the resultant curves would be similar to curve 3 of Figure 4. In addition to computing adjacency correlation based on the total number of fibers per section, such correlations can be made for any of the component fibers in the blended yarn. Such an analysis was made for yarn No. 2, the picker blend and yarn No. 5, the draw-frame blend. The resulting adjacency correlations, which are shown in Figure 5 for both the total number of fibers and for the nylon component, demonstrate that the actual correlation corresponds most closely to curve 3 of Figure 4 indicating that there is neither positive nor negative adjacency correlation in these yarns*.

Proportion of Nylon Component Versus Total

The relationship between the number of nylon fibers per cross-section and the total number of fibers per cross-section may be examined in two ways. First, we could consider the fact that if the total number of fibers per cross-section increases we would also expect to find a greater number of nylon fibers as well as a greater number of cotton fibers. On the other hand, if there is a tendency for sections of the yarn having a greater total number of fibers to contain a higher proportion of one or the other component fiber, then this must be in a sense associated with either the fiber content, the blend concentration or perhaps a yarn constructional factor. If such a preferential distribution of fibers existed it could be detected by plotting the number of nylon fibers in a section as a percentage against the absolute number of fibers in a section. This was done for two picker blend yarns, nominally 25% nylon (No. 1) and 50% nylon (No. 2) and for two draw-frame blend yarns, nominally 25% nylon (No. 4) and 50% nylon (No. 5). The results shown in Figures 6 and 7 demonstrate that there is no correspondence between the occurrence of fiber rich cross-sections and a higher proportion of either nylon or cotton in these richer sections. If the heavier sections were richer in either nylon or cotton, the general trend of the plotted points in Figures 6 and 7 could be characterized by a sloping average line. This is not the case, and the points appear to be randomly distributed about a line parallel to the total-number-of-fibers axis of the graph.

On the other hand, the premise that as the total number of fibers per section increases the number of nylon or cotton fibers per section increases is evident from examination of Figures 8 and 9.

*See Appendix H for sample computation

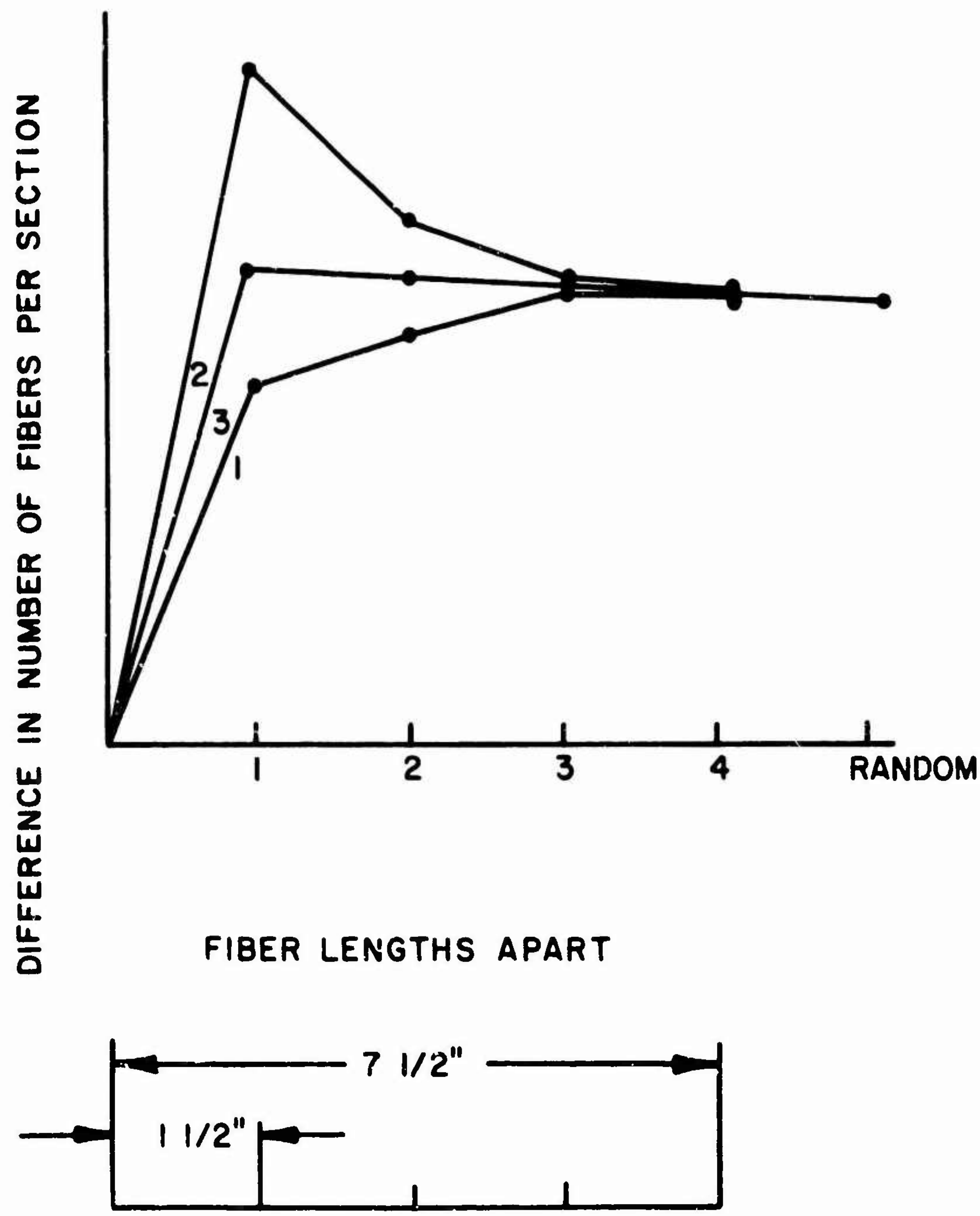


FIGURE 4, ILLUSTRATION OF TYPES OF ADJACENCY CORRELATION

FROM COPLAN AND BLOCH (1)

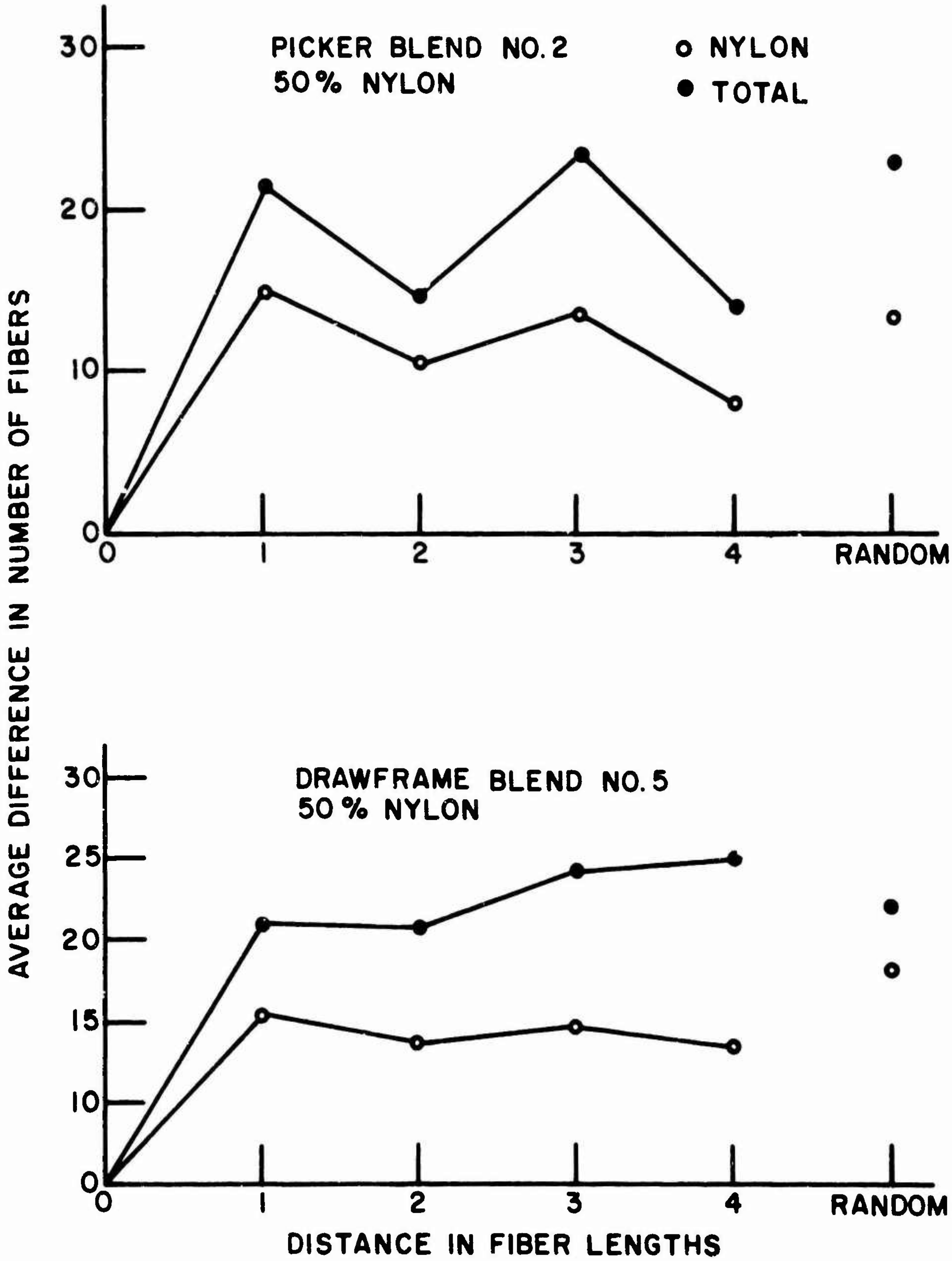


FIGURE 5, ADJACENCY CORRELATION OF PICKER AND DRAWFRAME BLENDS

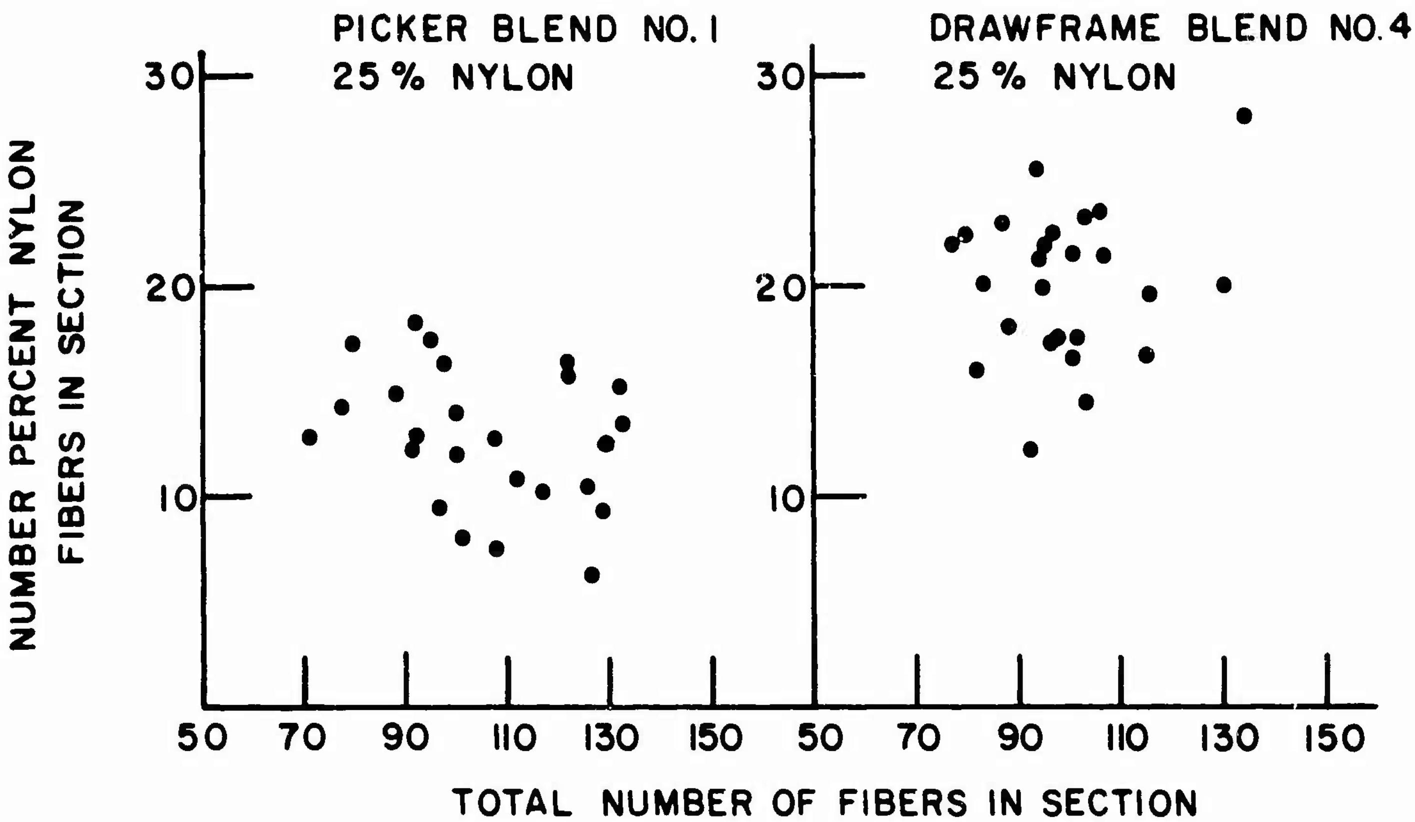


FIGURE 6, NUMBER % OF NYLON VS THE TOTAL NUMBER OF FIBERS

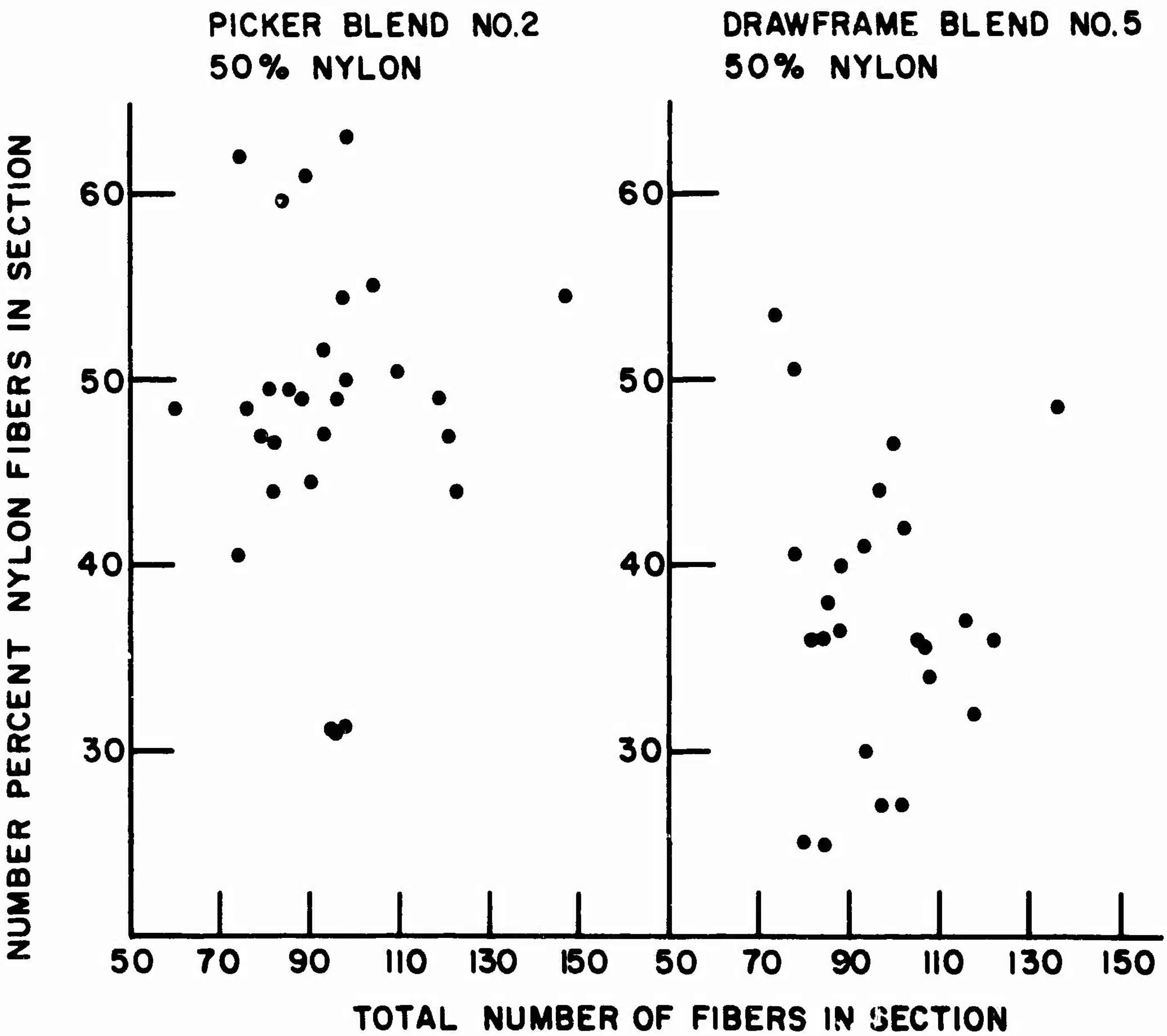


FIGURE 7. NUMBER % OF NYLON VS THE TOTAL NUMBER OF FIBERS

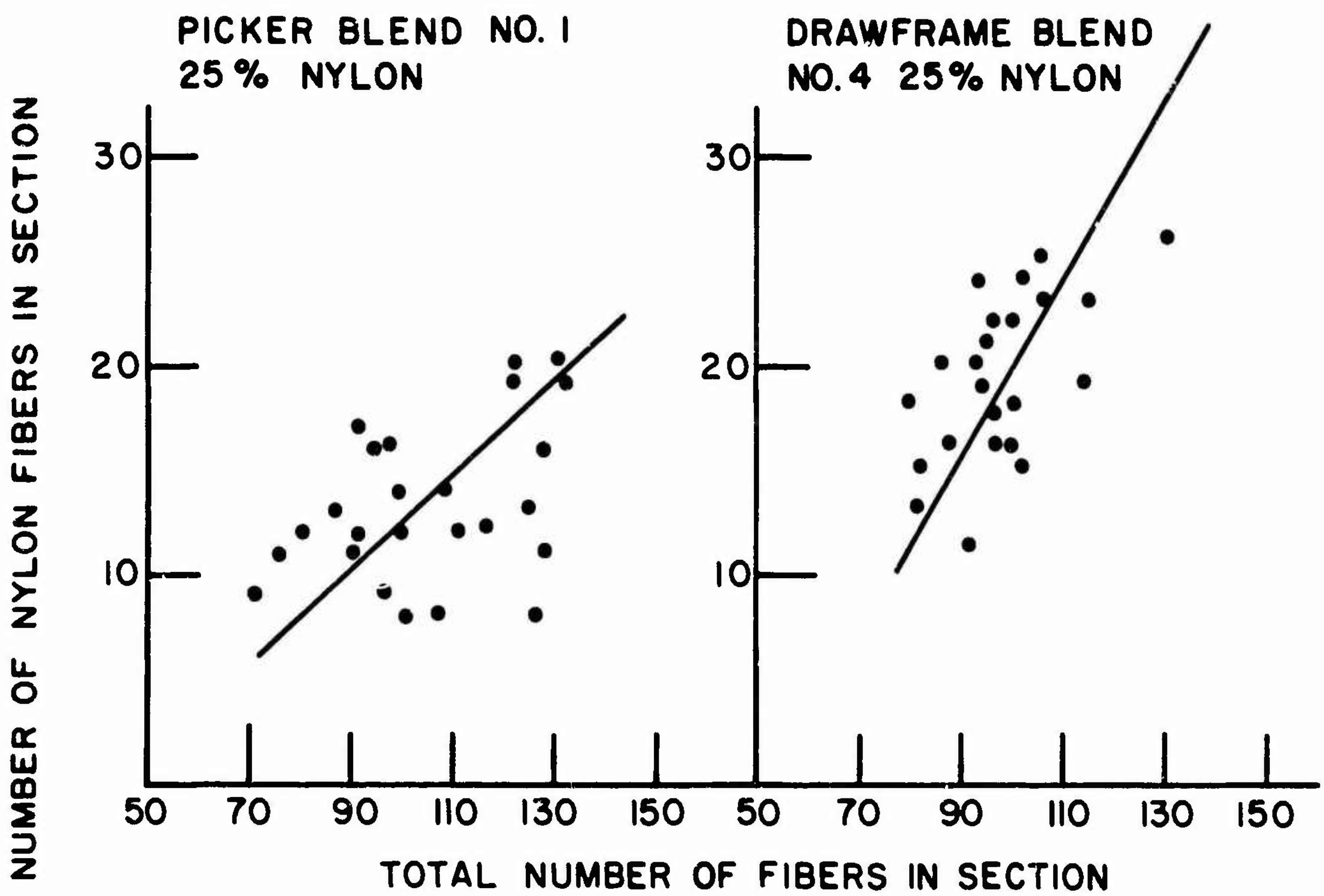


FIGURE 8. NUMBER OF NYLON FIBERS VS TOTAL NUMBER OF FIBERS

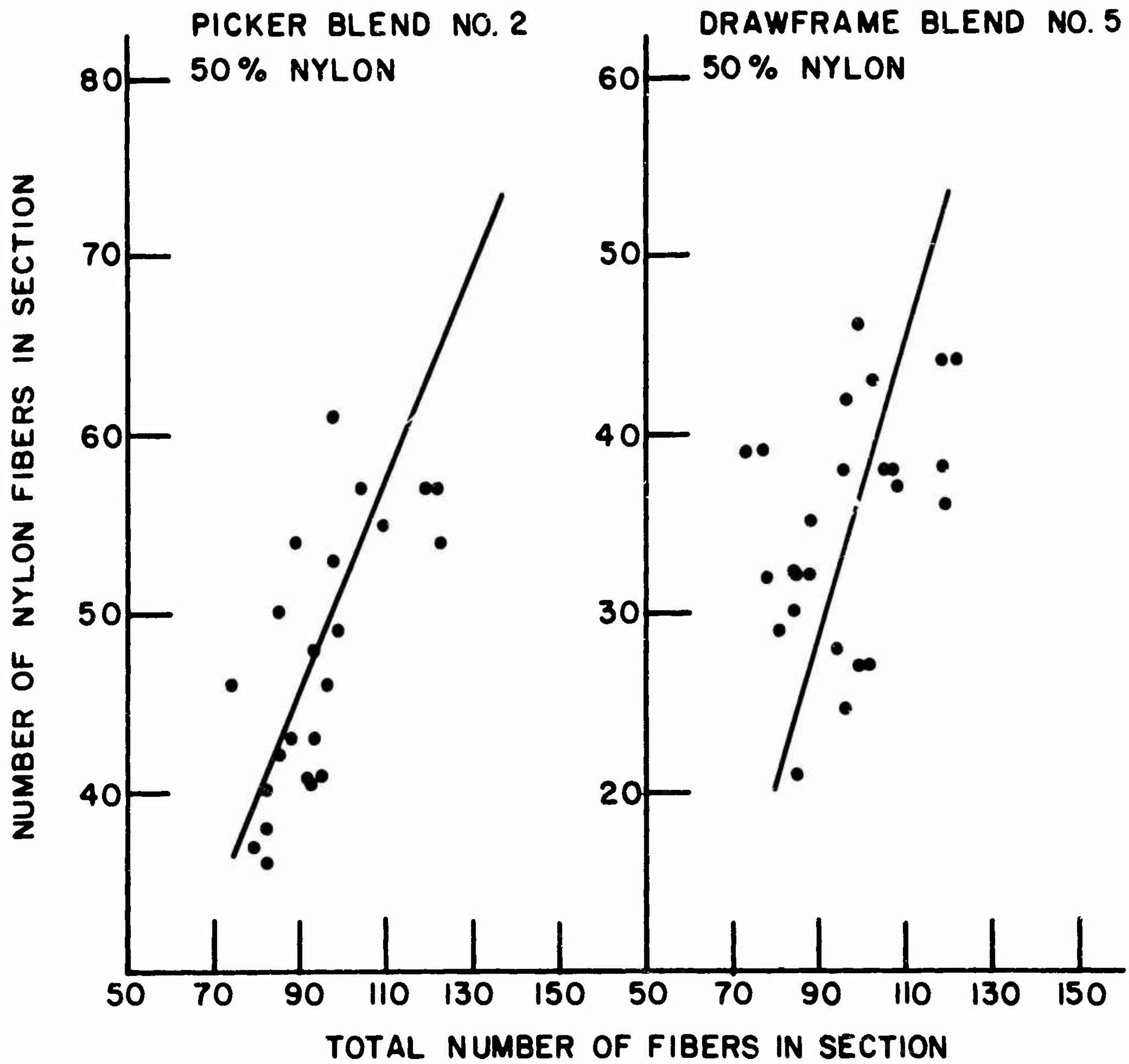


FIGURE 9. NUMBER OF NYLON FIBERS VS TOTAL NUMBER OF FIBERS

The definite upward trend of the plotted points occurs for both the picker and draw-frame blended yarns in the two blend compositions.

Index of Blend Irregularity

Since the randomness of blend distribution from section to section along a blended yarn is an important characteristic, an index of blend irregularity has been suggested by Coplan and Bloch (1) as a numerical criterion to evaluate this characteristic. The index of blend irregularity (IBI) was calculated as follows:

$$IBI = \sqrt{\frac{1}{n}\sum \frac{(T_i p - C_i)^2}{T_i pq}}$$

where

T_i = Total number of fibers at a section

C_i = Number of cotton fibers at that section

p = Average number fraction of cotton fibers for all sections

q = 1-p

n = Number of sections examined.

A value of IBI equal to 0 indicates perfect uniformity, 1 indicates complete randomness, and the excess beyond 1 represents the degree of departure from the ideal.

In this work all twenty-five sections of each of yarns 2 and 5 were examined. It was found that the IBI was 1.1 for the picker blend (No. 2) as against 1.5 for the draw-frame blend (No. 5), both being nominally 50% nylon - 50% cotton blend*.

This indicated that the picker blend is much closer to the theoretical complete randomness of blend than the draw-flame blend, for these two yarns.

It is worthwhile noting that the number of doublings (128) after blending for the draw-frame blended yarn is more than the average number of fibers per section (97); which excess is supposed to be necessary to achieve a random blend. Despite this the departure

*See Appendix H for sample computation

from the randomness of blend as indicated by the IBI, is significant.

Weight Percentage vs. Number Percentage Composition

When the average weight percentages of nylon and cotton fibers (Table I) for all twenty-five sections were computed, it was observed that the draw-frame blended yarns came closer to the expected blend composition than the picker blended yarns. In the picker blended yarns there was loss in either one or the other of the two components. This stands to reason, since the possible chances for loss of fibers after the carding operation are almost negligible compared to those before the drawing operation.

This is an important aspect from the practical point of view. The loss of nylon fibers in two yarns (1, 3) was illustrated by a higher loss of nylon fibers in the card waste (visual examination). A chemical test on No. 2 sliver and roving gave results similar to those shown in Table I.

B. Radial Distribution

Using the procedure followed by Coplan and Bloch (1), the radial distribution of blend composition in terms of numbers of fibers was found for each cross-section. An iterative process was used in which the blend composition of the innermost area of the cross-section was determined; the deviation in terms of the difference in numbers of nylon fibers in this inner area compared to that of the whole section was computed; then, going to the next concentric area and combining it with the innermost, the blend composition of the new combined areas in terms of numbers of nylon fibers was compared with that of the whole section again. This procedure was continued for every concentric area until the entire yarn was encompassed. Table II shows the actual and cumulative areas corresponding to the circles used for obtaining radial distribution.

The procedure was then reversed, considering only the outermost annulus first. The difference in its composition from that of the whole section was computed. The same procedure was continued inward and repeated until the entire section was traversed, from outside to inside.

Such deviations for corresponding areas were averaged for all twenty-five sections of a yarn, integrating both ways. These deviations were then plotted against the corresponding percents of total cross-sectional area (see Table II). As shown in Figures 10, 11, and 12 the deviations are plotted from left to right for integration from the inside to the outside of the yarn; and plotted from right to left for integration from outside to the inside of the yarn. Both the curves meet at the center which corresponds to the total area of the yarn.

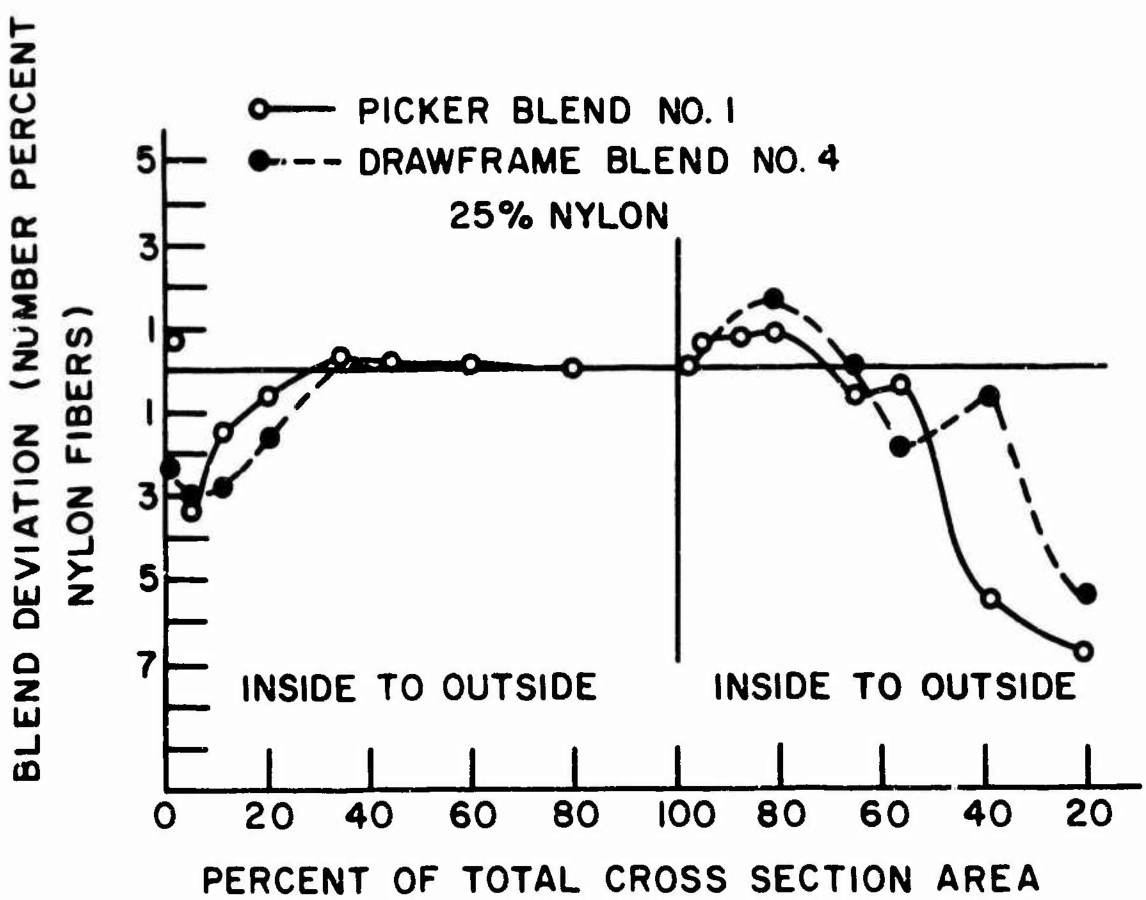


FIGURE 10. RADIAL DISTRIBUTION OF BLENDED YARNS

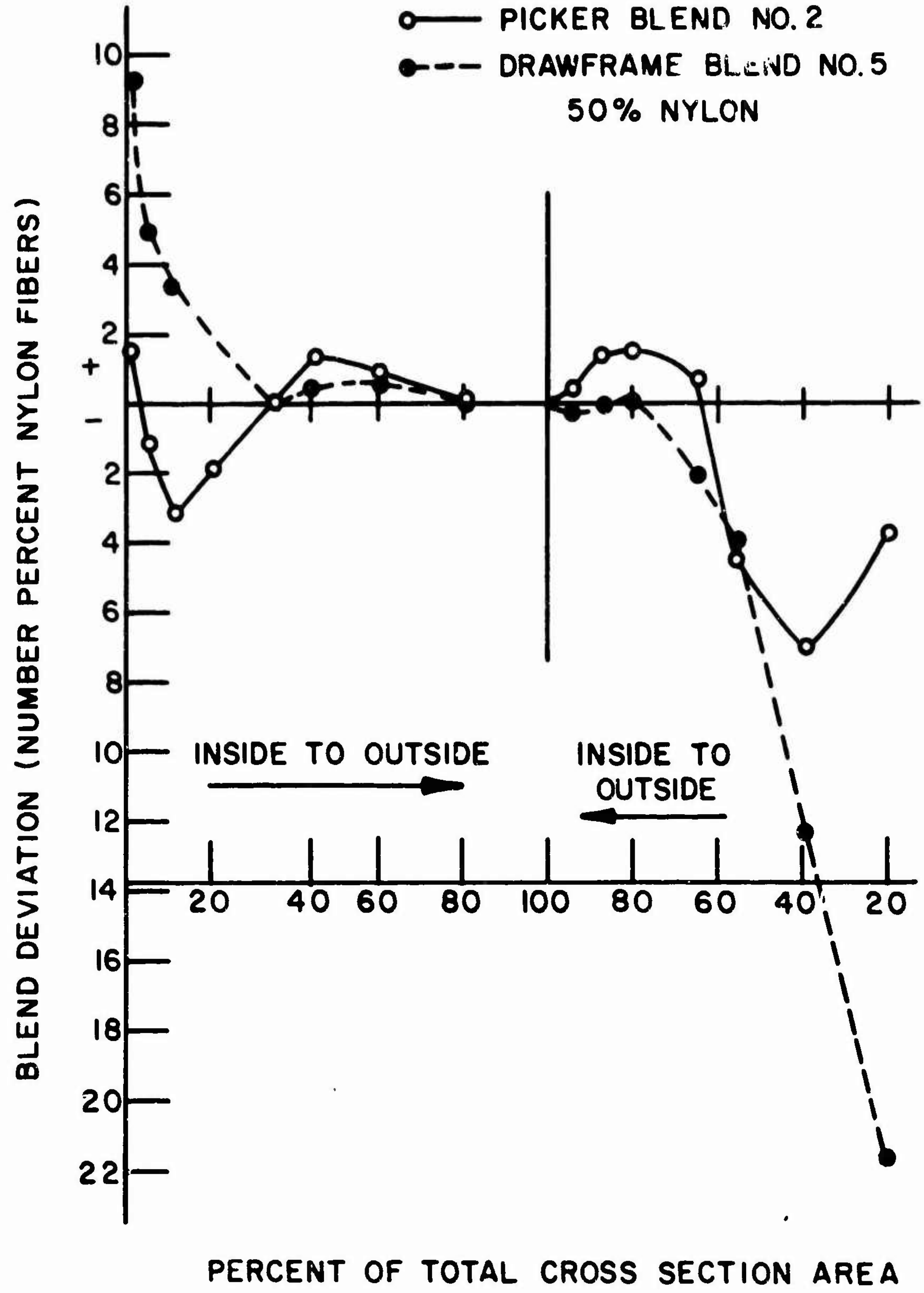


FIGURE II, RADIAL DISTRIBUTION IN BLENDED YARNS

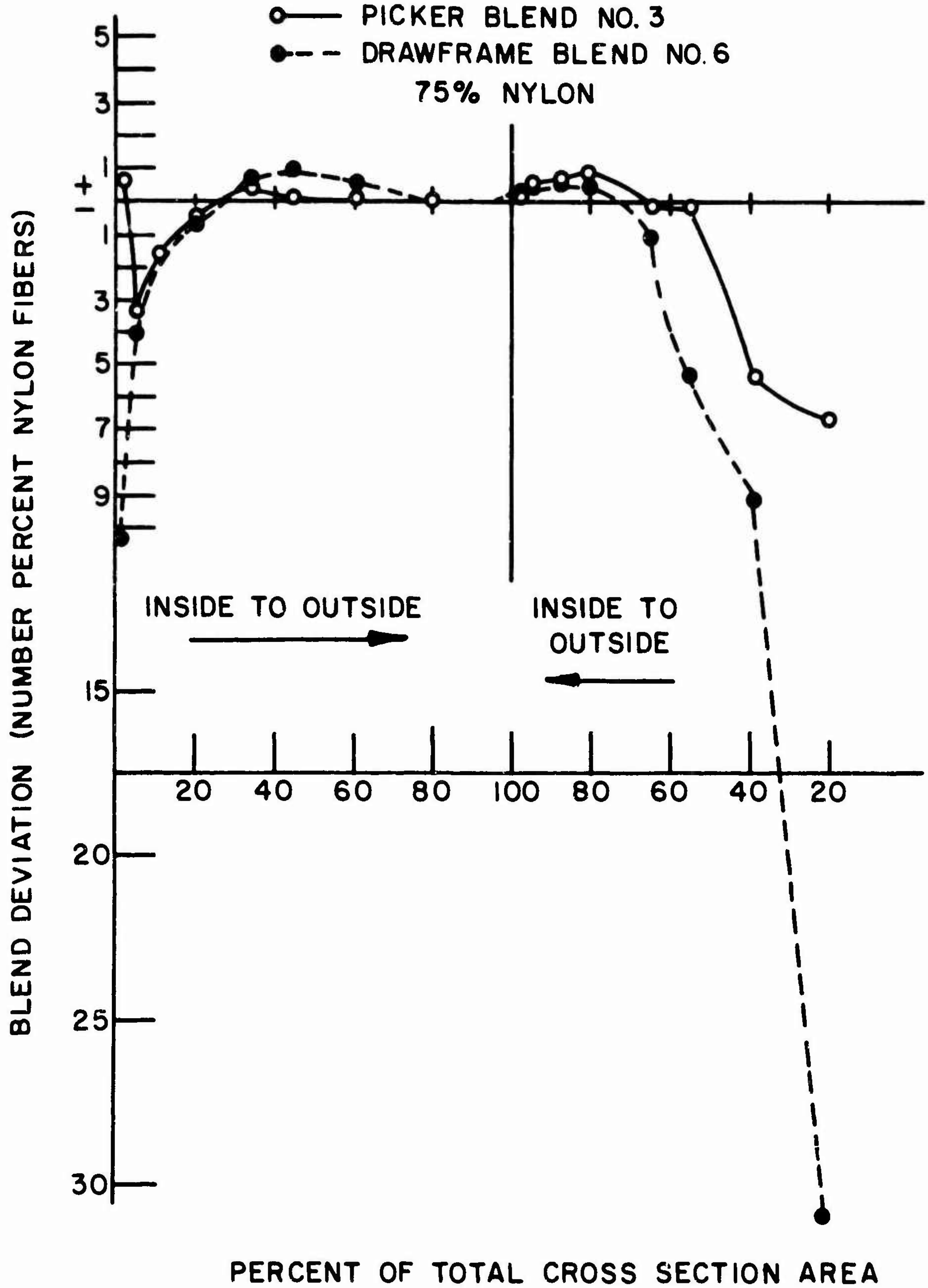


FIGURE 12, RADIAL DISTRIBUTION OF BLENDED YARNS

TABLE II

AREA EQUIVALENTS OF EQUAL DIAMETER CIRCLES

(ACTUAL AND CUMULATIVE)

Circle number	Dia. inches	Area in sq. in.	% cumulative area inside to outside	% cumulative area outside to inside
1	1	0.78	1.24	100.00
2	2	3.14	4.95	98.76
3	3	7.07	11.10	95.05
4	4	12.56	19.75	88.90
5	5	19.63	34.20	81.25
6	6	28.27	44.50	65.80
7	7	38.48	60.45	55.50
8	8	50.26	79.00	39.55
9	9	63.62	100.00	21.00

In examining Figures 10, 11, and 12 it should be recognized that the deviations indicated for the center portions of the yarn and the periphery may appear somewhat exaggerated when plotted, since the presence of 1 nylon fiber when expressed as a deviation in terms of percentage of the total number of fibers leads to very high deviations indeed. Nevertheless it is apparent that for all of the blended yarns, both picker and draw-frame types, there is a deficiency in nylon fibers at the periphery of the yarn and in all of the cases except one, there is a deficiency of nylon at the center regions of the yarns. The exception is draw-frame blended yarn No. 5. A most unusual behavior of all of the blended yarns, both picker and draw-frame blends, is the relative uniformity with respect to radial distribution in the regions of the cross-sections away from the center and from the periphery. Coplan and Bloch (1) did not observe this uniformity with the yarns that they worked with (nylon/wool and viscose/wool). In most of their tests the entire inner region of the yarn was rich in non-wool component, while the entire outer region of the yarn was deficient in non-wool component. In other words, the wool spun preferentially to the outside of the yarn. Further examination should be made of the observations regarding the nylon/cotton yarns in this study to make certain that the uniformity noted is not a testing artifact.

The raw data from which the radial distribution curves were computed are shown in Appendices N to S.

C. Rotational Distribution

For analysis of rotational distribution, the sector containing the highest number of nylon fibers was designated as 1, and then numbered consecutively in a clockwise manner from 2 to 8, inclusive. Thus, sectors 2 and 8 are adjacent to sector 1; sectors 3 and 7 are one sector removed and 4 and 6 are two sectors removed; and sector 5 is opposite sector 1. This system permits an examination of the deviations in blended fiber composition in moving around the yarn cross-section rotationally. A plot of average deviation in number of nylon fibers for the twenty-five sections of picker blend yarn No. 2 and draw-frame blend yarn No. 5 for the appropriate groups of numbered sectors is shown in Figure 13. It should be noted that the two sectors (2 and 8) adjacent to the sector (1) having the greatest number of fibers had approximately the average number of fibers for the entire cross section (indicated by 0 deviation) in the case of both the picker and draw-frame blends. The other sectors are somewhat deficient in nylon as indicated by the plotted points falling on the negative side of the average line (0 deviation). The interpretation of this observation would be that on the average in regions of higher concentration of nylon, the immediately adjacent sectors are not deficient in nylon, but tend to be somewhat higher in nylon than the other sectors. Also, the sectors that are deficient in nylon tend to be located in portions of the yarn cross-section opposite to the sectors of high nylon concentration.*

The raw data obtained in the laboratory from which the rotational distribution curves were computed are shown in Appendices T to Y.

IV. Conclusions

Longitudinal Distribution

(1) For the picker blend yarns having a nominal nylon content of 50%, the variation in blend composition (in terms of the number of fibers) was as great within 7½" length of yarn at distances one fiber length apart as among sections taken at random lengths.

(2) In the draw-frame blended yarns, having a nominal nylon content of 50%, variations within 7½" lengths at distances of one fiber length were less than variations among sections taken at random.

*See Appendix H for sample calculation

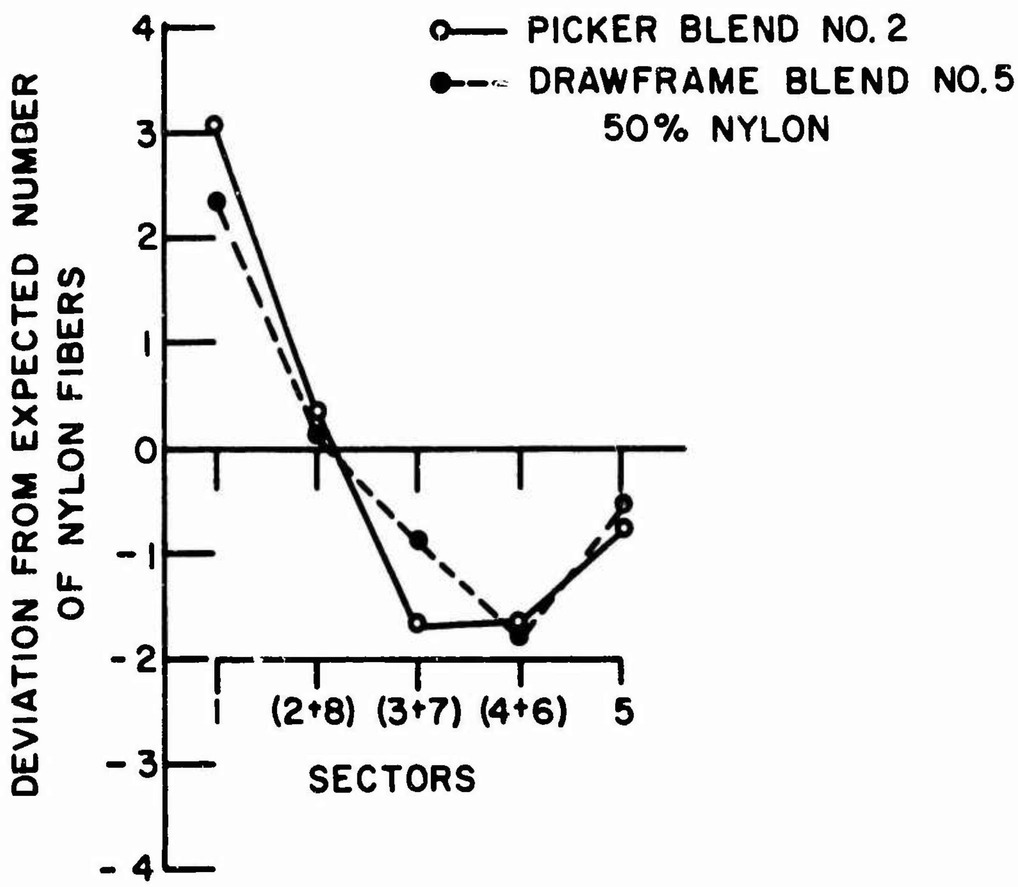


FIGURE 13. ROTATIONAL DISTRIBUTION

(3) Within $7\frac{1}{2}$" lengths of yarn, the variation in blend composition at sections $1\frac{1}{2}$" apart did not vary uniformly from one end of the $7\frac{1}{2}$" length to the other. In other words, the "adjacency correlation" was neither positive nor negative in the picker or draw-frame blends.

(4) The blend composition by number at a given section was unaffected by the total number of fibers at that section, for the yarns examined.

(5) The number of nylon or cotton fibers at a given section increased with the increase of total number of fibers at that section, for the yarns examined.

(6) For the nominal 50% nylon yarns, the picker blend was more uniform with respect to blend distribution than the draw-frame blend. The index of blend irregularity was 1.1 for the former and 1.5 for the latter.

(7) The three draw-frame blended yarns were closer to the nominal blend composition by weight than the corresponding picker blended yarns, despite the greater variation in blend composition of the former.

Radial Distribution

(1) For both picker and draw-frame blended yarns there was in general a deficiency of nylon fibers at the periphery and at the center of the yarns. However, the 50% nylon draw-frame blend showed an excess of nylon at the center of the yarn.

(2) All the yarns were quite uniform with respect to radial distribution in the regions of the cross-sections away from the center and the periphery.

Rotational Distribution

For the yarns examined, for both picker and draw-frame blends, the sectors immediately adjacent to the sectors of high nylon concentration were somewhat higher in nylon than the other sectors. The sectors directly opposite those of higher nylon content were somewhat lower in nylon.

V. Recommendations

(1) In view of the fact that the yarns produced in this study cover a range of variables of significant commercial

interest, it would be desirable to analyze their physical properties such as strength, elongation, elastic recovery, abrasion, etc.

(2) The yarns for this investigation were prepared at a single twist level. A blend distribution study for varying twist levels would be useful.

(3) Further investigation into the effects of manufacturing variables such as draft, sliver arrangement, and sliver mass on fiber distribution in yarns could provide valuable information.

(4) The yarns produced in this study represent a pedigreed series for investigating dimensional parameters of blended yarns such as diameter, specific volume and packing coefficient.

(5) Since not all of the blends were completely analyzed in this study, further work should entail completion of the longitudinal and rotational distributi[illegible] In addition it might be useful to examine variation within the $1\frac{1}{2}$-inch staple length.

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(6) Goodwin, J. A., "Cotton and Orlon Blends in Yarns" Bulletin, Lowell Tech. Inst., Series 61, No. 2 (1957).

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APPENDIX A

OPENING AND PICKING EQUIPMENT USED

Whitin blending feeder with axi-feed attachment: Model N-4

Saco Lowell ceiling condenser #11 with #6 air filter

Saco Lowell single process picker with:

(1) breaker section: two-bladed beater with #5 filter

(2) blending reserve section cross cut feed roll #7 super-sensitive evener with pedal feed, fringe roll, Kirschner beater, perforated sheet metal screws, bottom split lap preventer, pneumatic lap rack release.

Beater speeds and setting (with respect to feed roll)

	speed in r.p.m.	setting in inches
Breaker beater	1130	7/16
Blending reserve	240	
Finisher beater	740	7/16

APPENDIX B

CARD PARTICULARS FOR SACO LOWELL

Make: Saco Lowell 1916 model

Speeds: cylinder--160 r.p.m.
lickerin--330 r.p.m.
doffer---- 5 r.p.m.
flats-----2-3/4 inches per min.
doffer comb--1480 strokes/minute

Draft constant: 1526

Draft Gear: 13^T

Draft: 117.4

Sliver produced: 50 grains/yard

Production Pulley: 2-inch diameter

Production Gear: 24^T

Settings:

Feed plate to lickerin		.012"
Lickerin to cylinder		.007"
Back plate to cylinder		.022"
Mote knife	top	.012"
	bottom	.010"
Flats to cylinder (Back to front)		.010", .010", .010", .09", .09"
Front plate to cylinder		.029"
Screen to cylinder	back	.027"
	middle	.058"
	front	.187"
Doffer to cylinder		.007"
Doffer comb to doffer		.012"

APPENDIX C

CARD PARTICULARS FOR H & B CARD

Make:	H & B card	
Speeds:	cylinder 160 r.p.m.	
	lickerin 330 r.p.m.	
	doffer 5 r.p.m.	
	flats $2\frac{1}{2}$"/min.	
	fancy r.p.m.	
Settings:	Feed plate to lickerin	.012"
	Mote knives to lickerin top	.012"
	bottom	.010"
	Cylinder screen back	.029"
	middle	.068"
	front	.187"
	Lickerin screen nose	.012"
	front	.029"
	Lickerin to cylinder	.007"
	Back plate top and bottom	.029"
	Front plate top and bottom	.029"
	Flats to cylinder	.010"
	Fancy roll bite	$1\frac{1}{4}$"
	Doffer to cylinder	.005"
	Doffer comb to doffer	.017"

Sliver produced: 50 grains/yard

APPENDIX D

DRAW-FRAME PARTICULARS

Make: Saco Lowell, single head, 4 delivery frame

Drafting system: 3 over 4, Model DS-24 with positively driven, fine fluted second bottom roll

Front roll speed: 350 r.p.m.

Roll diameters:	Top (synthetic)	Bottom (steel)
Front	1-1/8"	1-1/8"
Second	2-1/8"	3/4"
Third	1-1/2"	1-3/8"
Back	--	1-3/8"

Roll Settings:	Front to 2nd	2nd to 3rd	3rd to back
Bottom	1-1/4"	1-1/2"	1-3/4"
Top	2-9/16"	1-5/16"	--

Top middle roll to bottom second roll: .019"

Draft constant: 343

Draft gears used: 38^T, 42^T and 44^T

Tension gears used: 74^T and 75^T

Sliver produced: 50 grains/yard

ARRANGEMENT OF NYLON AND COTTON SLIVERS ON DRAW-FRAME

75% Nylon 25% Cotton	N N C N N C N N*
50% Nylon 50% Cotton	C N C N C N C N
25% Nylon 75% Cotton	C C N C C N C C

*C = Cotton
N = Nylon

APPENDIX E

ROVING FRAME PARTICULARS

Make: Saco Lowell, 10" x 5" x 8" package, 48 spindles

Drafting system: 3 over 3, model FS-2, single apron

Spindle speed: 830 r.p.m.

Roll settings:	Front to middle	Middle to back
Top (synthetic)	1-3/4"	2-35/64"
Bottom (steel)	2-5/16"	1-31/32"

Draft constant: Back 90; Front 292.5

Draft gears used: Back 34^T; Front 43^T

Draft: Back 2.64; Front 6.8

Lay constant: 43.0

Lay gear used: 25^T

Constant for tension: 60.0

Tension gear used: 34^T

Twist constant: 46.1

Twist gears used:	29^T,	33^T and	35^T
Turns per inch:	1.59	1.40 and	1.32
Lots used:	100% cotton and 75% cotton 25% nylon	50% cotton 50% nylon and 25% cotton 75% nylon	100% nylon

Roving produced: 3.0 hank

Size of buttons on ends of top middle rolls: 15 with paper shims

APPENDIX F

RING FRAME PARTICULARS

Make: Fales and Jenks, 72 spindles, equipped with pneumafil and umbrella type creel, 3" gauge, 7" traverse and flange number 2 rings

Drafting system: Whitin superdraft, 3 over 3, double apron

Ring size: 1-3/4"

Spindle speed: 6900 r.p.m.

Draft constant: 1006.60

Draft gear used: 51^T

Draft: 19.7

Twist constant: 785.0

Twist gear used: 49^T

Turns per inch: 15.9

Twist multiplier: 3.0

Travelers used: Circle D, Victor 6/0

Yarn size: 28^s

APPENDIX G

YARN PREPARATION ROUTINE

Picker Blend		Draw-Frame Blend		Control	
Cotton	Nylon	Cotton	Nylon	100% Cotton	100% Nylon
Blending		Open & Clean	Open & Clean	Open & Clean	
Open & Clean		Picking	Picking	Picking	
Picking		Carding	Carding	Carding	
Carding		Prelim. Dwg.	Prelim. Dwg.	Breaker Dwg.	
Breaker Drawing		Blend Drawing		Finisher Dwg.	
Finisher Drawing		Finisher Drawing		Roving	
Roving		Sliver Reversal		Spinning	
Spinning		Roving			
		Spinning			

APPENDIX H

SAMPLE CALCULATIONS

Index of Blend Irregularity (IBI)

For yarn No. 2* $p = \frac{T-N}{T} = \frac{1162}{2341} = .496$

$q = .504$

for section Aa of yarn No. 2

$$\frac{(T_i p - C_i)^2}{T_i pq} = \frac{(98x.496-49)^2}{98x.496x.504}$$

$$= .0063$$

for section Ee of yarn No. 2

$$\frac{(T_i p - C_i)^2}{T_i pq} = \frac{82x.496-44}{82x.496x.504}$$

$$= .5538$$

for yarn No. 2 $IBI = \frac{.0063 + ... + .5538}{25} = 1.1$

Adjacency Correlation:

For yarn No. 2. Differences in total number of fibers between sections Aa and Ab, Ab and Ac, Ac and Ad, Ad and Ae are respectively 6, 7, 36, and 24. Similar differences for the remaining groups B, C, D, and E of sections of yarn No. 2 can be found. So average difference in total number of fibers in sections one fiber length apart can be calculated as follows:

$(6 + 17 + 36 + 34 + ... + 16)/20 = 21.4$

Rotational Distribution:

For section Ca of yarn No. 2**, expected number of nylon fibers in each sector is 40/8 = 5. In sector designated as number 1 (containing highest number of nylon fibers) the deviation is 2. In sectors designated as 2 and 8 the deviation is 6 + 4 - 10 = 0. In sectors designated as 3 and 7 the deviation is -2. In sectors designated as 4 and 6 the deviation is -1. In sectors designated as 8 the deviation is -1. The deviations for other sections can be calculated similarly, and respective averages can be computed.

*Appendix O

**Appendix U

APPENDIX I

PRODUCTION ORGANIZATION

3.0%	Spinning Twist Contraction	.97	28	Final count
	Draft Spinning	19.3	29	Yarn count at front roll
			1.50	Equivalent hank roving fed
			X 2	Doublings fed to spinning
	Draft Roving Frame	18	3.00	Hank no. delivered from roving frame
			.167	Hank no. or
			50	grain sliver from finisher drawing
			X 8.0	Draft in finisher drawing
	Doubling Finisher Drawing	8	400	
			50	Grain sliver preliminary drawing
			X 8.0	Draft in blend drawing
	Doubling	8	400	
			50	Grain sliver preliminary drawing
			X 8.0	Draft in preliminary drawing
	Doubling	8	400	
			50	Grain card sliver
			X 109.5	Draft card

APPENDIX I - (Cont'd)

4.0% Card Waste	.96	15475	
Grains/ounces	437.5	15700	grains/yard lap
		13.0	ounces/yard lap from picker

APPENDIX J

EQUATIONS USED IN COMPUTER PROGRAM FOR

DETERMINING RADIAL BLEND DISTRIBUTION

Equation integrating from inside to outside of yarn:

$$\sum_{i=1}^{i=9} \left(\frac{N}{T}\right)_i \times 100 - \frac{N_s}{T_s} \times 100$$

Equation integrating from outside to inside of yarn:

$$\sum_{i=9}^{i=1} \left(\frac{N}{T}\right)_i \times 100 - \frac{N_s}{T_s} \times 100$$

where:

N = number of nylon fibers in each ring (1 or 2 or 3, etc.)

T = Total number of fibers in each ring (1 or 2 or 3, etc.)

N_s = Number of nylon fibers in the section

T_s = Total number of fibers in the section

For section Ee of yarn number 6, integrating from inside to outside of yarn, the deviations were calculated as follows:

for ring 1, deviation $= \frac{3}{4} \times 100 - \frac{48}{68} \times 100$

$= 75.00 - 70.59$

$= 4.41$

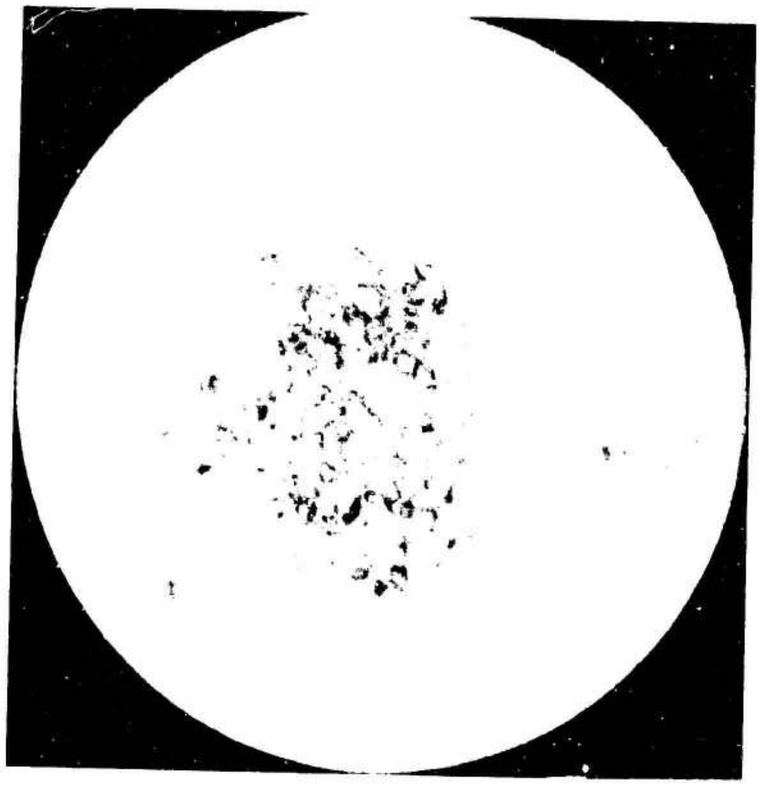
for ring 2, deviation $= \frac{8}{11} \times 100 - \frac{48}{68} \times 100$

$= 72.73 - 70.59$

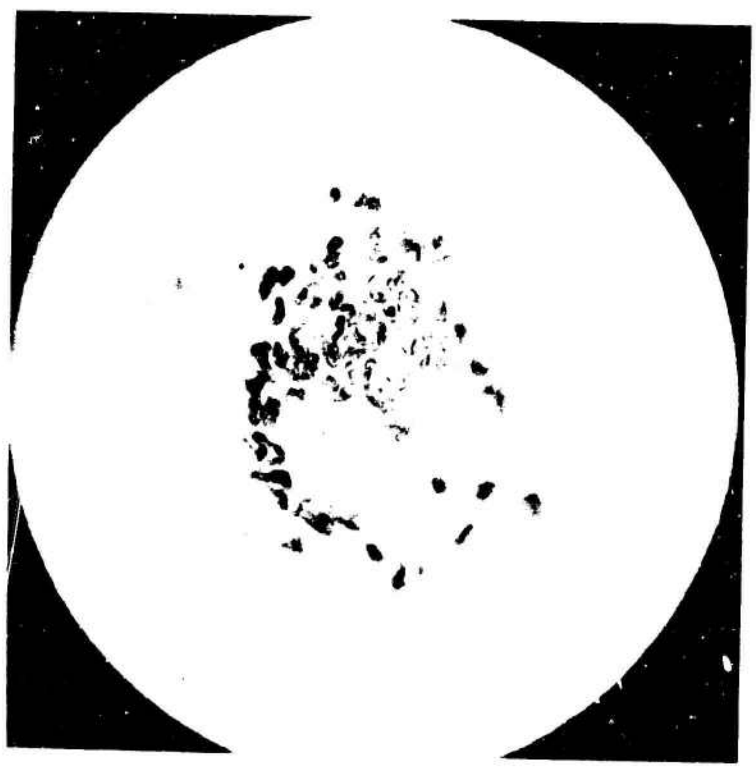
$= 2.14$

APPENDIX K

PHOTOGRAPHS OF SELECTED YARN CROSS-SECTIONS OF NOMINAL 25% NYLON



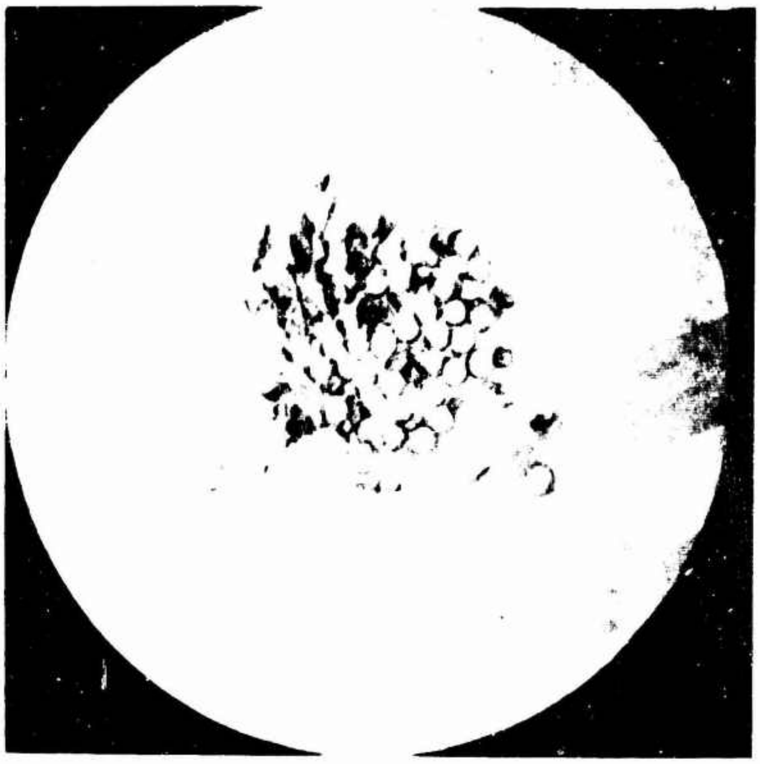
PICKER BLEND



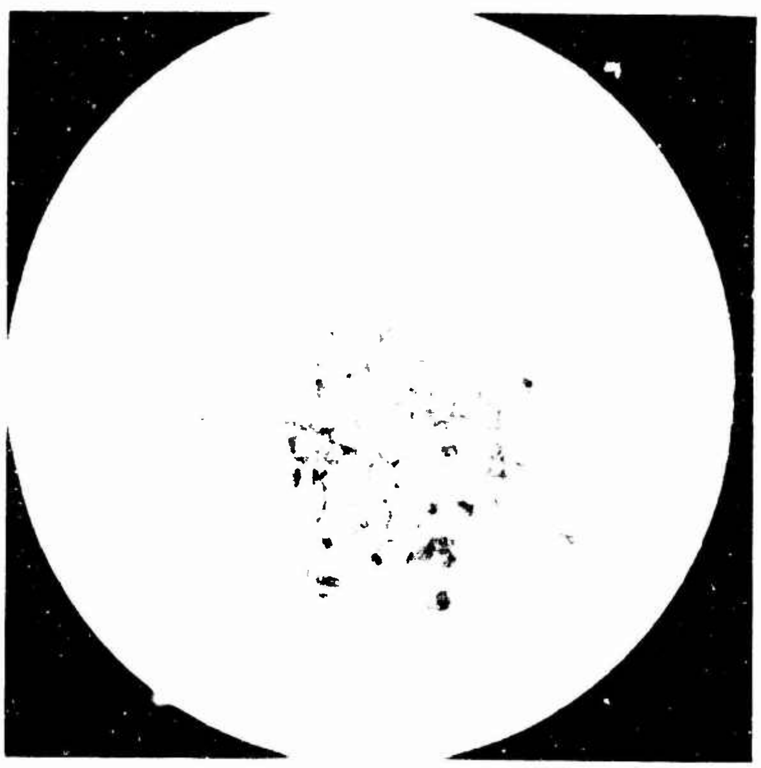
DRAW-FRAME BLEND

APPENDIX L

PHOTOGRAPHS OF SELECTED YARN CROSS-SECTIONS
OF NOMINAL 50% NYLON



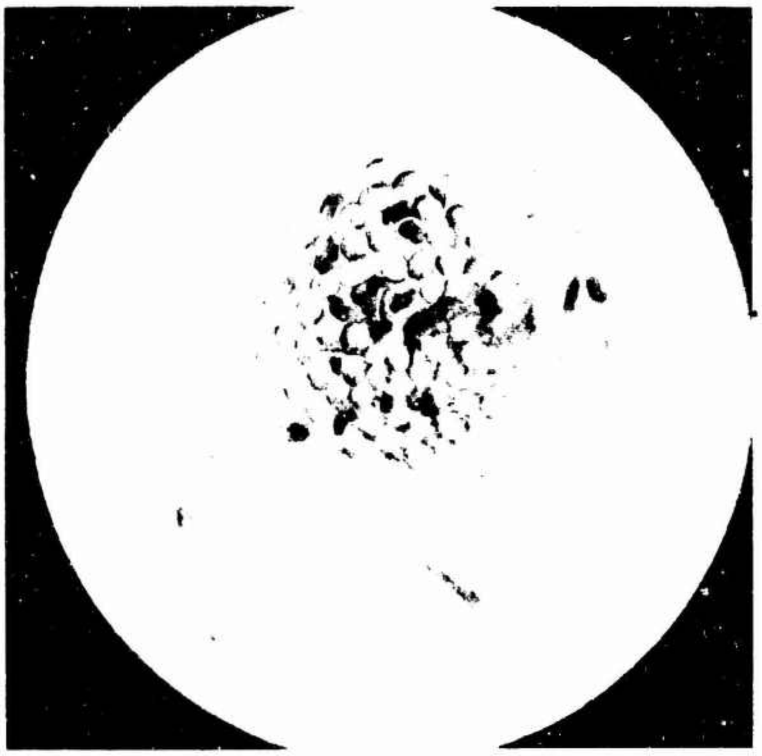
PICKER BLEND



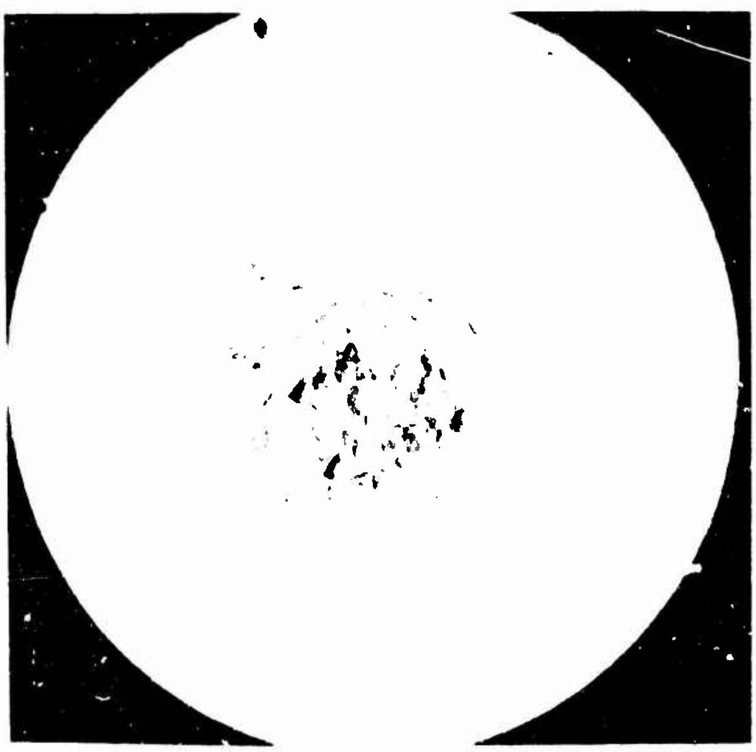
DRAW-FRAME BLEND

APPENDIX M

PHOTOGRAPHS OF SELECTED YARN CROSS-SECTIONS
OF NOMINAL 75% NYLON



PICKER BLEND



DRAW-FRAME BLEND

APPENDIX N

RAW DATA FOR RADIAL DISTRIBUTION CURVES OF 25% NYLON--PICKER BLEND (YARN NO. 1)

Yarn		1		2		3		4		5		6		7		8		9		Total	
No.		N	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T
	a	--	4	--	10	4	21	2	17	6	19	2	9	--	1	--	--	--	--	14	81
	b	--	4	--	10	3	13	3	20	3	19	7	26	3	14	1	13	--	4	20	123
A	c	--	4	--	12	2	21	2	21	4	25	2	15	1	10	--	1	1	3	12	112
	d	--	2	--	9	1	14	2	20	4	19	1	21	1	10	--	2	--	--	9	97
	e	--	2	--	14	3	13	2	17	3	17	1	6	--	1	--	--	--	1	9	71
	a	--	4	1	9	1	17	5	19	4	26	2	23	--	8	1	2	--	1	14	109
	b	--	3	--	10	1	18	4	23	2	20	1	21	--	5	--	1	--	--	8	101
B	c	1	3	1	8	3	20	4	21	5	20	2	21	--	5	--	--	--	--	16	98
	d	1	4	--	11	1	14	1	21	1	25	2	23	2	24	--	4	--	1	8	127
	e	1	3	2	9	--	10	4	16	3	17	3	21	--	6	--	4	--	2	13	88
	a	--	1	2	9	1	11	4	18	2	24	2	29	3	24	2	10	--	3	16	129
	b	--	6	1	9	1	16	1	26	6	26	2	21	1	15	--	5	1	2	13	126
C	c	--	3	--	8	2	17	3	22	2	25	2	20	2	16	--	3	1	3	12	117
	d	--	3	2	8	--	11	3	21	3	22	3	24	1	8	--	3	--	--	12	100
	e	1	5	--	8	2	11	3	27	3	23	4	18	3	30	2	11	--	--	18	133
	a	--	5	3	7	1	15	4	19	5	26	2	34	3	19	1	4	1	3	20	132
	b	--	4	1	7	3	15	1	23	2	20	1	30	--	6	--	3	--	--	8	108
D	c	--	3	--	12	--	19	2	24	4	26	2	20	3	17	--	5	--	3	11	129
	d	--	6	1	8	4	15	3	20	4	23	2	14	2	7	--	2	--	--	16	95
	e	1	2	1	7	1	20	5	22	3	23	5	23	2	13	--	9	1	3	19	123
	a	1	1	--	7	1	11	4	16	3	17	4	17	3	16	1	3	--	4	17	92
	b	--	1	--	6	2	10	4	17	1	5	1	13	2	9	1	6	--	--	11	77
E	c	1	5	--	10	4	12	2	15	3	23	3	22	1	8	--	5	--	--	14	100
	d	--	4	3	7	2	13	1	25	2	25	2	15	1	2	--	--	--	--	11	91
	e	1	2	1	12	2	17	1	23	5	26	1	10	1	2	--	--	--	--	12	92

APPENDIX O

RAW DATA FOR RADIAL DISTRIBUTION CURVES OF 50% NYLON--PICKER BLEND (YARN NO. 2)

Yarn No.		1		2		3		4		5		6		7		8		9		Total	
		N	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T
	a	2	3	4	8	4	14	12	20	10	17	11	20	4	11	1	4	1	1	49	98
	b	--	3	5	8	3	13	8	15	14	21	16	23	9	14	1	4	1	3	57	104
A	c	1	3	2	6	5	14	5	18	10	19	15	21	11	25	7	12	1	2	57	121
	d	2	3	6	10	4	10	10	18	12	19	7	15	1	4	--	3	--	3	42	85
	e	1	2	2	7	4	15	9	17	12	18	13	23	7	18	8	16	1	2	57	119
	a	2	3	4	7	6	10	7	17	11	21	8	18	7	16	--	2	1	2	46	96
	b	--	4	3	9	8	10	10	18	11	17	12	16	9	14	1	1			54	89
B	c	2	4	1	8	7	15	4	12	5	12	7	12	3	6	--	3	1	2	30	74
	d	1	1	5	6	7	8	6	17	4	13	4	9	2	3	--	1	--	2	29	60
	e	1	2	1	7	6	14	7	17	9	17	9	12	2	5	1	1	1	1	37	76
	a	1	3	6	7	5	12	9	16	9	18	7	13	2	8	--	3	1	1	40	81
	b	1	2	3	9	5	13	11	19	7	14	12	24	16	22	10	16	15	28	80	147
C	c	1	1	6	8	2	11	9	18	9	17	12	22	3	8	1	6	--	2	43	93
	d	1	2	3	9	4	12	11	15	17	25	9	18	6	10	1	4	1	2	53	97
	e	2	2	5	6	5	11	6	12	12	18	8	18	4	15	1	4	--	1	43	88
	a	2	3	3	8	7	11	8	17	8	18	5	14	2	5	--	--	2	3	37	79
	b	2	2	3	7	5	9	7	18	9	19	10	24	10	20	4	11	4	12	54	122
D	c	1	4	5	7	5	13	8	19	9	22	5	16	4	9	--	--	--	--	37	90
	d	--	3	4	8	5	9	9	17	12	17	10	22	7	16	5	10	3	7	55	109
	e	1	2	5	7	4	12	11	14	9	21	14	21	3	10	--	3	1	3	48	93
	a	1	4	4	6	6	11	11	14	8	17	9	13	5	7	1	1	1	1	46	74
	b	1	2	3	8	5	14	7	17	6	14	10	20	4	6	--	1	--	--	36	82
E	c	2	2	2	7	7	14	8	13	13	18	11	17	4	8	1	1	2	4	50	84
	d	1	2	2	8	7	15	10	17	15	20	14	15	10	18	2	2	1	1	62	98
	e	1	2	3	7	6	14	7	18	8	18	9	16	4	7	--	--	--	--	38	82

APPENDIX P

RAW DATA FOR RADIAL DISTRIBUTION CURVES OF 75% NYLON---PICKER BLEND (YARN NO. 3)

Yarn No.		1 N	1 T	2 N	2 T	3 N	3 T	4 N	4 T	5 N	5 T	6 N	6 T	7 N	7 T	8 N	8 T	9 N	9 T	Total N	Total T
	a	1	2	7	9	6	10	8	17	10	14	7	9	5	6	1	1	--	--	45	68
	b	1	4	5	6	11	12	13	21	9	13	12	14	--	3	--	--	2	2	53	75
A	c	1	3	5	8	10	13	11	14	13	16	4	9	2	6	2	3	--	--	48	72
	d	1	3	4	6	8	9	12	20	12	16	12	18	5	12	2	3	2	2	58	89
	e	1	4	4	9	10	12	8	19	15	20	11	14	5	7	2	3	1	1	57	89
	a	1	1	4	6	9	12	8	16	10	14	13	21	5	15	1	6	1	3	52	94
	b	--	4	2	6	7	11	12	18	13	17	13	17	11	14	2	4	2	4	62	95
B	c	1	1	4	7	5	9	11	16	9	14	7	11	3	4	1	3	2	3	43	68
	d	2	3	2	6	2	5	9	15	12	21	10	14	8	11	2	12	--	6	47	93
	e	1	2	3	9	4	13	9	12	7	12	5	8	2	6	2	8	1	1	34	71
	a	2	4	3	5	7	13	10	16	6	10	3	8	--	2	--	1	--	--	31	59
	b	3	3	3	6	7	8	8	15	10	16	12	19	5	12	1	5	2	3	51	87
C	c	2	3	4	4	6	9	12	15	12	19	10	20	9	17	7	12	3	6	65	105
	d	2	2	3	6	7	9	7	12	7	13	7	12	3	5	3	6	--	--	39	65
	e	1	2	5	7	5	13	8	12	11	20	17	23	5	11	6	8	--	--	58	96
	a	2	2	4	9	5	10	7	18	13	20	13	18	9	14	2	8	--	2	55	101
	b	1	1	3	9	7	13	10	16	13	20	12	16	4	10	1	3	3	8	54	96
D	c	1	1	6	6	8	11	10	18	11	22	16	20	7	15	3	7	4	7	66	107
	d	2	3	2	7	8	14	11	18	11	21	6	22	9	20	2	9	1	1	52	115
	e	1	2	6	7	7	12	11	21	12	20	13	19	6	12	2	7	1	5	59	105
	a	3	3	3	8	10	11	9	13	11	17	2	9	7	10	5	6	2	4	52	81
	b	2	2	5	8	6	10	5	11	10	16	8	11	2	3	1	2	3	5	42	68
E	c	1	3	3	6	9	10	11	14	12	15	12	16	6	8	2	5	1	2	57	79
	d	1	2	7	8	7	8	12	16	9	17	7	9	3	4	--	1	1	1	47	66
	e	2	3	3	8	8	9	13	17	5	15	8	12	7	9	3	5	4	6	53	84

APPENDIX Q

RAW DATA FOR RADIAL DISTRIBUTION CURVES OF 25% NYLON--DRAW-FRAME BLEND (YARN NO.4)

Yarn No.		1 N	1 T	2 N	2 T	3 N	3 T	4 N	4 T	5 N	5 T	6 N	6 T	7 N	7 T	8 N	8 T	9 N	9 T	Total N	Total T
	a	--	4	2	9	1	15	5	20	6	25	5	23	3	4	--	1	--	--	22	101
	b	--	4	2	7	3	12	5	16	2	20	6	26	5	18	--	4	--	--	23	107
A	c	--	4	1	9	7	13	2	13	6	19	2	15	1	10	1	3	--	1	20	87
	d	1	5	3	10	3	14	5	16	6	20	1	15	0	9	0	4	--	2	19	95
	e	--	6	2	11	4	13	3	23	2	15	5	14	2	4	1	5	1	3	20	94
	a	1	4	4	9	1	18	6	19	5	21	5	18	2	19	2	18	--	5	26	131
	b	1	5	2	10	2	17	5	19	7	26	--	19	1	5	--	--	--	--	18	101
B	c	--	4	2	10	2	10	5	23	6	21	7	26	9	23	3	17	--	--	34	134
	d	1	4	1	7	2	20	4	16	3	24	4	15	2	10	--	2	--	--	17	98
	e	2	4	--	7	1	19	3	23	3	21	7	18	--	5	1	4	--	--	17	101
	a	--	4	6	9	2	14	2	18	3	19	--	26	1	9	--	3	1	1	15	103
	b	1	4	--	9	2	15	6	21	9	20	4	16	--	7	2	2	--	--	24	94
C	c	--	5	--	12	2	14	5	17	6	18	2	13	--	2	--	2	--	--	15	83
	d	--	3	1	11	2	14	3	23	3	18	1	13	1	8	--	1	--	1	11	92
	e	1	4	2	7	3	13	1	23	2	21	9	28	3	14	2	6	--	--	23	116
	a	1	3	1	8	2	8	2	12	4	14	3	22	--	9	--	5	--	1	13	82
	b	1	3	--	12	2	15	7	21	6	16	1	8	--	2	--	--	--	--	17	77
D	c	1	4	1	9	1	13	3	18	4	20	7	15	1	13	1	14	--	9	19	115
	d	1	1	3	6	3	1	2	11	5	18	3	16	5	21	--	9	--	4	22	97
	e	1	4	--	8	3	17	3	18	8	15	2	19	--	8	--	7	--	1	17	97
	a	--	1	--	8	4	14	2	20	5	24	5	17	1	4	2	5	2	2	21	95
	b	1	3	--	10	1	18	4	18	6	22	3	16	5	12	4	6	1	1	25	106
E	c	--	4	--	9	4	13	5	16	4	15	5	19	--	3	--	1	--	--	18	80
	d	--	4	1	9	1	16	4	18	6	23	7	17	4	10	--	3	1	3	24	103
	e	--	5	1	8	3	13	3	16	1	23	6	16	2	4	--	1	--	2	16	88

APPENDIX R

RAW DATA FOR RADIAL DISTRIBUTION CURVES OF 50% NYLON--DRAW-FRAME BLEND (YARN NO. 5)

Yarn No.		1 N	1 T	2 N	2 T	3 N	3 T	4 N	4 T	5 N	5 T	6 N	6 T	7 N	7 T	8 N	8 T	9 N	9 T	Total N	Total T
	a	1	2	4	9	1	14	5	19	8	22	5	19	7	18	5	15	--	1	36	119
	b	1	2	3	8	5	17	7	17	10	24	3	11	1	5	--	1	--	--	30	85
A	c	1	1	3	8	3	11	4	15	4	18	11	19	11	23	--	10	1	2	38	107
	d	1	3	5	7	2	7	3	15	3	21	2	15	3	9	1	3	--	--	20	80
	e	1	3	1	6	4	13	2	22	8	19	10	23	6	22	6	9	--	1	38	118
	a	1	4	1	6	7	12	5	20	5	20	5	17	3	15	--	5	--	--	27	99
	b	1	3	--	7	4	12	3	18	8	21	10	22	2	9	--	2	--	--	28	94
B	c	1	2	5	7	2	9	8	21	7	17	4	17	5	5	--	--	--	--	32	78
	d	1	3	3	9	5	14	4	19	5	21	4	21	5	13	--	2	--	--	27	102
	e	--	3	5	7	7	14	8	17	10	24	4	13	4	15	--	2	--	--	38	95
	a	2	2	4	5	6	15	8	17	7	22	8	30	7	16	2	8	--	3	44	118
	b	1	3	7	10	6	15	7	25	12	25	7	18	2	5	1	1	--	--	43	102
C	c	2	4	3	9	8	12	8	19	12	27	15	31	11	20	6	12	1	2	66	136
	d	1	2	2	11	8	15	5	20	4	22	--	11	--	3	--	--	--	--	21	84
	e	1	3	4	8	5	13	8	21	8	21	4	13	2	8	--	1	--	--	32	88
	a	1	2	2	12	5	11	7	21	7	26	8	19	8	18	5	8	1	5	44	122
	b	1	3	1	12	5	15	5	18	11	24	10	17	3	11	1	7	--	1	37	108
D	c	1	1	5	9	7	14	5	21	4	20	10	22	4	10	2	6	--	2	38	105
	d	1	3	3	6	7	12	4	17	12	21	10	20	3	7	--	6	2	4	42	96
	e	1	3	3	9	7	15	6	18	10	19	4	16	1	5	--	--	--	--	32	85
	a	2	3	7	10	4	11	8	14	5	10	9	14	1	4	3	5	--	2	39	73
	b	1	3	1	7	3	13	4	14	9	18	11	19	4	9	--	2	2	3	35	88
E	c	1	3	4	6	4	11	8	15	16	21	4	12	--	4	1	4	1	1	39	77
	d	1	3	2	8	6	12	5	16	6	20	7	15	1	5	1	2	--	--	29	81
	e	2	3	4	7	7	12	5	15	6	16	9	21	9	16	3	7	1	2	46	99

APPENDIX S

RAW DATA FOR RADIAL DISTRIBUTION CURVES OF 75% NYLON--DRAW-FRAME BLEND (YARN NO. 5)

Yarn No.		1 N	1 T	2 N	2 T	3 N	3 T	4 N	4 T	5 N	5 T	6 N	6 T	7 N	7 T	8 N	8 T	9 N	9 T	Total N	Total T
	a	1	2	5	6	6	8	10	17	13	21	17	22	11	14	4	7	1	2	68	99
	b	1	2	4	6	7	10	10	17	9	14	10	14	6	8	--	4	--	--	47	75
A	c	2	2	6	7	9	12	9	12	16	20	13	15	8	12	2	2	1	1	66	83
	d	1	5	5	8	7	10	11	13	16	21	7	15	9	14	1	4	1	2	58	92
	e	--	3	4	7	7	9	9	13	14	18	14	21	3	8	2	4	--	--	53	83
	a	1	1	7	9	7	9	10	12	12	20	15	22	14	18	20	23	8	9	94	123
	b	1	3	5	9	6	9	12	16	8	10	14	21	12	20	1	1	--	--	59	97
B	c	1	1	3	6	5	6	4	13	7	14	8	14	5	6	2	2	--	--	35	62
	d	1	3	2	5	4	5	9	13	10	19	14	23	5	7	3	6	1	2	49	83
	e	1	2	4	5	5	9	12	14	10	16	8	14	6	15	1	4	--	1	47	80
	a	2	2	5	8	5	12	10	16	9	15	8	13	1	2	2	2	--	--	42	70
	b	2	3	4	8	9	13	10	14	8	16	5	8	--	--	--	--	--	--	38	62
C	c	1	2	5	6	7	12	12	15	17	18	14	17	12	15	10	12	--	2	78	99
	d	3	3	2	6	4	9	10	16	13	20	13	16	6	8	--	1	--	--	51	79
	e	2	3	4	9	6	11	10	17	12	19	17	24	10	20	4	8	--	3	65	114
	a	1	4	5	6	8	10	11	17	14	18	11	21	11	18	3	8	--	--	64	102
	b	1	3	3	7	7	10	10	15	18	22	16	20	11	18	2	9	5	5	73	109
D	c	1	2	6	8	5	10	11	15	12	16	16	21	17	21	6	8	2	2	76	103
	d	1	3	5	6	11	14	7	11	17	23	10	21	6	16	1	1	4	4	62	99
	e	1	4	4	7	8	14	12	19	11	20	9	18	3	5	--	--	--	--	48	87
	a	2	3	4	8	11	14	11	16	11	12	11	16	4	8	3	5	--	--	57	82
	b	1	2	8	9	4	11	7	16	12	19	13	24	9	18	4	4	1	2	59	105
E	c	2	4	6	9	8	13	11	13	11	17	12	22	3	3	5	6	1	2	59	89
	d	1	3	4	5	7	10	10	16	13	17	12	18	4	7	--	4	--	1	51	81
	e	3	4	5	7	4	8	5	12	15	18	10	11	5	4	--	--	1	1	48	68

APPENDIX T

RAW DATA FOR ROTATIONAL DISTRIBUTION OF 25% NYLON--PICKER BLEND (YARN NO. 1)

Yarn		1		2		3		4		5		6		7		8		Total	
No.		N	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T
	a	1	9	2	11	--	10	--	10	1	7	2	11	4	11	4	12	14	81
	b	5	15	2	17	3	16	2	14	--	16	1	19	1	15	6	11	20	123
A	c	1	11	--	13	3	17	1	15	1	12	2	11	3	18	1	15	12	112
	d	2	9	--	13	--	14	1	13	2	12	1	11	2	13	1	12	9	97
	e	--	8	2	10	1	10	1	8	1	7	3	9	1	10	--	9	9	71
	a	3	13	--	16	2	12	3	10	1	12	2	18	--	14	3	14	14	109
	b	1	12	2	11	1	10	--	12	1	9	--	15	2	19	1	13	8	101
B	c	2	11	--	11	2	15	6	7	1	18	2	11	2	12	1	13	16	98
	d	--	15	--	15	2	13	3	14	--	12	1	16	--	25	2	17	8	127
	e	1	11	1	10	2	11	1	9	--	11	4	11	2	12	2	13	13	88
	a	2	15	4	20	3	15	4	11	--	11	1	20	2	19	--	18	16	129
	b	3	13	3	18	1	18	1	16	--	12	1	12	2	19	2	18	13	126
C	c	1	13	--	16	4	18	2	8	3	13	--	18	1	17	1	14	12	117
	d	2	16	2	12	--	12	2	9	1	11	2	14	2	15	1	11	12	100
	e	3	20	1	18	2	12	2	14	2	15	2	18	3	22	3	14	18	133
	a	1	14	5	17	2	13	1	12	3	17	3	22	3	20	2	17	20	132
	b	1	16	1	15	2	11	1	10	1	12	--	15	2	14	--	15	8	108
D	c	--	16	2	23	--	11	2	15	3	17	1	14	3	20	--	13	11	129
	d	3	11	3	16	2	12	1	9	1	12	2	15	2	12	2	8	16	95
	e	--	18	1	14	3	14	3	13	4	14	2	15	3	20	3	15	19	123
	a	2	13	3	12	--	11	1	12	3	9	2	11	3	11	3	13	17	92
	b	--	9	1	12	2	9	1	8	3	7	1	15	2	7	1	10	11	77
E	c	1	11	3	16	2	10	1	12	--	12	1	14	4	16	2	9	14	100
	d	3	9	1	10	--	10	1	8	1	16	2	14	1	14	2	10	11	91
	e	--	12	2	8	1	11	1	10	3	12	2	13	1	13	2	13	12	92

APPENDIX U

RAW DATA FOR ROTATIONAL DISTRIBUTION OF 50% NYLON--PICKER BLEND

Yarn		1				3		4		5		6		7		8		Total	
No.		N	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T	N	T
	a	4	13	7	11	6	12	6	10	7	9	8	13	8	17	3	13	49	98
	b	8	14	6	11	7	10	3	10	8	16	9	17	8	13	8	13	57	104
A	c	6	13	5	12	4	11	7	13	9	20	10	19	11	18	5	15	57	121
	d	5	8	7	9	4	11	5	11	4	9	6	12	6	13	5	12	42	85
	e	7	10	9	17	6	14	5	14	5	10	8	18	6	21	11	15	57	119
	a	5	9	3	13	3	13	5	8	6	11	11	13	6	16	7	12	46	96
	b	6	10	7	8	7	10	6	10	5	12	6	14	10	13	7	12	54	89
B	c	--	7	5	10	3	13	1	7	5	8	5	10	7	13	4	6	30	74
	d	2	6	1	5	5	10	1	7	3	8	6	7	8	8	3	9	29	60
	e	2	8	4	9	3	8	5	7	6	11	6	13	7	11	4	8	37	75
	a	6	13	6	8	3	8	4	11	4	9	7	13	6	12	4	7	40	81
	b	10	18	8	15	12	17	6	19	6	15	10	20	14	24	14	19	80	147
C	c	7	11	5	16	4	9	3	8	6	10	5	14	10	16	3	9	43	93
	d	7	15	7	12	6	12	5	6	5	12	10	14	10	15	3	11	53	97
	e	5	9	5	10	3	7	6	11	8	13	8	13	6	15	2	10	43	88
	a	4	8	5	8	4	9	3	6	4	10	3	9	7	15	7	14	37	79
	b	7	14	7	20	7	13	3	9	5	11	8	20	9	19	8	16	54	122
D	c	4	11	5	8	5	11	2	11	4	11	4	10	7	16	6	12	37	90
	d	9	12	10	17	6	15	4	9	3	13	6	14	9	18	8	11	55	109
	e	6	12	7	13	6	11	7	9	6	10	5	17	6	12	5	9	48	93
	a	5	9	7	10	2	7	7	13	10	11	4	8	6	9	5	7	46	74
	b	3	9	8	12	3	8	3	12	2	8	3	11	8	12	6	10	36	82
E	c	4	12	6	9	5	9	7	10	11	16	6	9	3	9	8	10	50	84
	d	6	10	9	12	8	14	9	12	5	9	11	12	9	13	5	16	62	98
	e	3	10	5	9	7	12	4	11	3	11	3	10	6	10	7	9	38	82

APPENDIX V

RAW DATA FOR ROTATIONAL DISTRIBUTION OF 75% NYLON--PICKER BLEND (YARN NO. 3)

Yarn No.		1 N	1 T	2 N	2 T	3 N	3 T	4 N	4 T	5 N	5 T	6 N	6 T	7 N	7 T	8 N	8 T	Total N	Total T
A	a	8	8	6	8	3	6	3	10	9	12	6	7	6	9	4	8	45	68
	b	5	11	7	10	9	11	5	8	8	10	6	10	7	8	6	7	53	75
	c	6	7	4	9	6	9	7	10	3	7	6	9	8	10	8	11	48	72
	d	7	11	7	11	7	10	8	11	6	12	7	9	8	14	8	11	58	89
	e	8	10	4	8	12	13	6	11	8	11	6	12	8	15	5	9	57	89
B	a	5	8	8	12	5	4	3	8	6	10	10	17	7	13	8	12	52	94
	b	8	9	9	13	9	11	9	11	5	12	6	12	10	12	6	15	62	95
	c	6	10	6	11	4	6	5	6	7	8	5	10	5	8	5	9	43	68
	d	5	9	7	10	6	15	7	14	5	12	8	11	7	10	2	12	47	93
	e	4	7	8	10	5	10	4	7	2	8	4	10	4	8	3	11	34	71
C	a	4	6	5	10	4	6	4	5	4	7	2	9	5	8	3	8	31	59
	b	7	10	6	15	5	10	5	9	9	11	3	11	10	10	6	11	51	87
	c	7	14	5	10	9	15	10	14	9	10	9	13	9	15	7	14	65	105
	d	5	7	4	4	4	9	5	9	4	8	7	9	4	7	6	12	39	65
	e	8	13	8	11	7	13	8	13	5	12	7	11	8	10	7	13	58	96
D	a	5	11	8	13	5	14	7	13	7	9	11	13	6	14	6	14	55	101
	b	4	10	7	11	9	15	6	10	4	14	11	15	6	8	7	13	54	96
	c	7	15	11	16	9	15	7	7	8	12	12	16	7	15	5	11	66	107
	d	5	10	4	15	7	11	5	17	10	14	8	17	8	16	5	15	52	115
	e	4	10	9	14	8	15	10	13	9	13	6	17	5	13	8	10	59	105
E	a	9	11	7	9	6	9	7	11	5	8	8	13	2	7	8	13	52	81
	b	6	7	8	11	3	7	5	9	7	8	2	9	7	10	4	7	42	68
	c	6	9	10	12	7	8	6	11	3	7	8	11	8	11	9	10	57	79
	d	6	9	4	7	8	9	6	8	4	6	10	11	6	10	3	6	47	66
	e	8	11	7	9	7	12	9	13	5	8	5	9	2	9	10	13	53	84

APPENDIX W

RAW DATA FOR ROTATIONAL DISTRIBUTION OF 25% NYLON--DRAW-FRAME BLEND(YARN NO.4

Yarn No.		1 N	1 T	2 N	2 T	3 N	3 T	4 N	4 T	5 N	5 T	6 N	6 T	7 N	7 T	8 N	8 T	Total N	Total T
	a	3	7	3	12	2	15	2	13	2	14	3	15	4	15	3	10	22	101
	b	2	16	1	7	--	7	2	9	3	16	5	17	5	18	5	16	23	107
A	c	4	12	2	14	4	10	1	9	1	6	3	9	2	14	3	13	20	87
	d	3	15	2	15	3	10	2	8	--	10	3	9	3	16	3	12	19	95
	e	1	12	3	10	1	14	3	12	4	11	3	9	1	15	4	11	20	94
	a	2	17	--	15	6	13	4	15	6	14	2	16	4	18	2	23	26	131
	b	3	11	1	12	3	15	1	10	--	10	3	17	4	15	3	11	18	101
B	c	5	16	5	10	--	15	3	15	4	21	5	19	8	21	4	17	34	134
	d	1	18	2	10	3	10	1	7	1	9	3	10	1	18	5	16	17	98
	e	1	13	1	12	2	11	3	10	3	14	3	11	3	15	1	15	17	101
	a	2	11	2	15	2	13	1	15	2	15	2	11	1	12	3	11	15	103
	b	2	14	2	12	3	10	1	12	3	11	5	11	3	11	5	13	24	94
C	c	2	11	2	10	2	11	2	6	2	9	4	12	--	11	1	13	15	83
	d	1	10	1	14	1	9	--	12	1	13	--	8	4	14	3	12	11	92
	e	6	15	3	10	--	11	2	15	3	13	4	20	3	16	2	16	23	116
	a	--	9	7	14	1	9	1	6	1	13	3	11	--	11	--	9	13	82
	b	2	13	4	7	2	10	1	5	1	11	2	9	1	15	4	7	17	77
D	c	1	10	3	18	5	14	4	17	4	17	2	15	--	13	--	11	19	115
	d	1	13	1	14	2	12	6	9	4	15	3	14	3	11	2	9	22	97
	e	--	9	1	16	1	16	2	11	3	8	4	13	5	13	1	11	17	97
	a	4	12	5	15	5	11	1	11	--	10	1	11	2	15	3	10	21	95
	b	2	10	3	14	4	13	5	14	2	15	2	13	3	17	4	10	25	106
E	c	2	8	5	9	1	11	1	11	--	10	3	7	4	12	2	12	18	80
	d	2	10	2	10	4	15	4	11	2	12	2	14	3	18	5	13	24	103
	e	1	11	1	9	5	10	4	12	--	12	1	10	4	13	--	11	16	88

APPENDIX X

RAW DATA FOR ROTATIONAL DISTRIBUTION OF 50% NYLON--DRAW-FRAME BLEND(YARN 105)

Yarn No.		1 N	1 T	2 N	2 T	3 N	3 T	4 N	4 T	5 N	5 T	6 N	6 T	7 N	7 T	8 N	8 T	Total N	Total T
	a	2	15	2	11	6	14	3	12	3	9	9	20	6	21	5	17	36	119
	b	1	9	4	10	6	10	4	14	5	11	1	13	4	8	5	9	30	85
A	c	4	12	3	13	5	11	3	14	6	12	8	19	6	14	3	14	38	107
	d	3	7	2	7	2	8	1	7	2	11	5	14	3	16	2	10	20	80
	e	2	12	4	13	2	18	5	11	5	16	8	19	7	17	5	12	38	118
	a	2	11	3	8	5	11	5	11	3	13	4	17	3	15	2	13	27	99
	b	4	12	2	13	2	9	1	5	4	10	5	15	5	18	5	13	28	94
B	c	5	9	4	9	2	8	3	10	3	10	5	10	5	9	5	13	32	78
	d	4	10	1	12	1	13	2	11	7	17	5	13	4	13	3	13	27	102
	e	4	13	6	14	4	12	5	14	3	6	6	13	5	12	5	11	38	95
	a	8	13	4	18	4	19	1	13	5	11	8	18	8	12	6	14	44	118
	b	4	15	6	15	6	13	3	12	7	9	6	16	8	12	3	11	43	102
C	c	8	18	6	16	5	16	10	18	8	14	10	17	9	18	10	19	66	136
	d	3	7	4	10	2	11	4	10	2	5	--	15	2	15	4	11	21	84
	e	5	13	4	13	2	9	3	9	4	8	5	9	5	15	4	12	32	88
	a	7	13	4	19	7	13	6	15	4	13	7	17	4	17	5	15	44	122
	b	3	17	3	12	4	14	5	14	6	15	7	10	5	13	4	13	37	108
D	c	6	15	2	12	9	13	4	13	2	13	5	12	6	13	4	14	38	105
	d	6	9	4	13	3	13	5	12	3	10	4	12	8	14	9	13	42	96
	e	4	7	6	11	2	10	3	9	3	12	3	10	4	13	7	13	32	85
	a	8	9	7	11	4	7		9	3	7	3	9	6	11	3	8	39	73
	b	6	9	3	10	2	8	4	10	4	12	5	12	4	14	5	10	35	88
E	c	3	8	5	12	5	11	4	6	4	8	6	13	6	9	5	9	39	77
	d	3	7	4	12	2	11	2	10	3	13	6	8	6	14	3	6	29	81
	e	6	13	5	13	6	13	5	12	6	12	5	12	8	15	4	8	46	99

APPENDIX Y

RAW DATA FOR ROTATIONAL DISTRIBUTION OF 75% NYLON--DRAW-FRAME BLEND (YARN NO. 6)

Yarn No.		1 N	1 T	2 N	2 T	3 N	3 T	4 N	4 T	5 N	5 T	6 N	6 T	7 N	7 T	8 N	8 T	Total N	Total T
	a	10	10	10	14	6	12	4	9	8	13	10	15	9	14	11	12	68	99
	b	8	8	6	9	7	10	6	12	6	10	4	11	5	8	5	7	47	75
A	c	8	10	6	6	7	9	11	11	10	12	12	12	4	11	8	12	66	83
	d	8	18	4	13	6	9	5	9	8	13	11	11	8	9	8	10	58	92
	e	8	9	5	6	6	11	4	11	5	13	8	12	9	10	8	11	53	83
	a	9	13	11	13	14	18	15	20	9	15	15	17	13	13	8	14	94	123
	b	8	11	6	9	7	13	6	12	6	13	10	14	6	12	10	13	59	97
B	c	3	6	7	9	5	7	5	6	6	10	5	9	4	8	--	7	35	62
	d	8	10	8	11	6	10	8	14	8	10	5	7	2	13	4	8	49	83
	e	5	10	8	10	7	8	6	11	5	11	5	7	6	10	5	13	47	80
	a	5	8	8	11	3	8	6	6	2	10	4	8	6	10	8	9	42	70
	b	3	6	6	9	2	10	5	6	6	10	8	9	6	8	2	4	38	62
C	c	8	12	10	13	9	14	9	11	8	13	12	13	12	13	10	10	78	99
	d	8	9	7	9	5	11	6	9	5	10	7	9	8	12	5	10	51	79
	e	5	15	3	20	9	14	5	14	9	12	13	13	11	14	10	12	65	114
	a	8	13	6	12	5	16	11	11	11	15	7	16	7	9	9	10	64	102
	b	8	12	7	11	11	14	12	17	10	12	8	13	8	16	9	14	73	109
D	c	6	8	8	16	13	16	8	11	10	10	12	17	8	13	11	12	73	103
	d	8	12	10	13	6	14	6	9	7	10	9	17	9	14	7	10	62	99
	e	7	12	5	7	7	9	8	12	6	11	5	13	5	12	5	11	48	87
	a	7	10	1	9	6	10	7	8	9	11	9	11	13	16	5	7	57	82
	b	6	11	9	14	12	15	7	11	5	10	7	13	8	15	5	14	59	105
E	c	12	16	8	8	8	11	5	11	3	9	7	11	9	12	6	9	59	89
	d	7	11	7	10	4	10	2	9	5	8	9	11	10	11	7	10	51	81
	e	6	8	6	9	5	7	5	7	4	7	10	12	4	8	7	9	48	68

APPENDIX Z

EXPLANATION OF TABLES IN APPENDICES N TO Y INCLUSIVE

Appendices N to S inclusive (radial distribution)

(a) Columns numbered 1 to 9 inclusive contain the number of nylon fibers designated as "N" and the total number of fibers designated as "T" for each ring. From the innermost, numbers go "1" to the outermost numbered "9".

(b) Rows designated by capital letters A to E inclusive represent groups of sections taken at random from the three yarn bobbins.

(c) Sub-rows designated by lower case letters a to e inclusive represent five sequential sections taken at distances of one fiber length ($1\frac{1}{2}$-inches) apart from each random group.

Appendices T to X inclusive (rotational distribution)

(a) Columns numbered 1 to 8 inclusive contain the number of nylon fibers designated as "N" and the total number of fibers designated as "T" for each pie shaped sector. Sector numbered "1" was selected arbitrarily, and the balance of the section were numbered sequentially in a clockwise fashion. For analysis the sector containing the greatest number of nylon fibers was redesignated as number "1" and then the balance of the sectors were numbered sequentially in a clockwise fashion.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT Blended yarns were produced from a good grade of cotton ($1\frac{1}{2}$-inch American Egyptian) and nylon 420 ($1\frac{1}{2}$-inch - 2.3 denier) with percentages of nylon of 0, 25, 50, 75, and 100. Blending was done at the picker and at the drawframe for each blend composition. All yarns were spun to a nominal 28^s count (cotton system) with a twist-multiplier of 3.0. Cross-sections of these yarns were examined microscopically to determine the longitudinal, radial, and rotational distributions of the fibers.

It was observed that the yarns produced by picker blending were more uniform in composition than those produced by draw-frame blending. However, the draw-frame blends conformed more closely to the planned nominal composition of the yarns. In the picker blends the variation in blend composition was almost the same in sections taken one fiber length apart ($1\frac{1}{2}$") or taken randomly at any length greater than $7\frac{1}{2}$". But, in the draw-frame blends the former (short length variation) was less than the latter (long length variation). However, in neither the picker nor in the draw-frame blends was "adjacency" correlation noted; i.e., adjacent sections were no more uniform in composition than sections 2, 3, or 4 fiber lengths removed.

The radial distribution analyses indicated that for both the picker and draw-frame blends there was in most instances a deficiency of nylon at the periphery and at the center of the yarns. However, away from the center and periphery the blend composition closely matched the average blend composition of the yarns. The rotational distribution analyses showed that sectors having a high nylon concentration were found to be flanked by sectors of slightly more than average nylon concentration, for the yarns examined.

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Comparison	8					
Distribution	8		6			
Longitudinal	0					
Radial	0					
Rotational	0					
Fibers	9		6			
Cotton	9		6			
Nylon	9		6			
Picker blended	0		0			
Draw-frame blended	0		0			
Physical properties			7			
Fabrics			7			
Clothing			4			
Protective			0			
Military requirements			4			

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