Influence of Yarn Size on the Relative Contributions of Six Cotton Fiber Properties To Strength of Carded Yarn

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SUMMARY AND CONCLUSIONS

The relation of certain cotton-fiber properties to yarn strength is not fixed but varies with yarn size, with yarn construction, and with textile processing. Effects of such factors on the relationships between fiber and yarn properties, therefore, are important matters to cotton research and testing programs, as well as to commercial textile processing. Further knowledge is needed, however, if cotton quality evaluations obtained from routine spinning tests are to represent their highest degree of comparability and reliability, and if fullest consideration is to be given to cotton fiber properties in processing and testing.

This is a report of the results obtained from studies to determine the influence of yarn size on the relation of 6 fiber properties to skein strength of carded yarn; and a discussion of discrepancies in results obtained for 14s, the coarsest yarn studied. These findings suggest various problems for further experimentation and exploratory study, in the continuing effort to provide the factual basis needed for developing improved, more standardized, and better controlled methods of testing in cotton spinning laboratories and commercial textile plants.

Included in this study are data representing a total of 842 cottons and 3,267 lots of long-draft processed, carded, warp singles yarn, ranging in size from 14s to 60s, with a semi-hard twist, for 3 crop years, 1948-50. Supplementary analyses were made with the data representing 277 cottons and 1,108 lots of yarn from the 1948 crop, stratified by variety and 3 dates of harvesting, for special analytical purposes.

Six elements of raw-cotton quality were used in the correlation analyses as independent variables. They were, as follows: Upper half mean length, length uniformity ratio, fiber fineness (weight per inch--Micronaire), fiber strength (Pressley--zero gauge), percentage of mature fibers (standard method), and grade index.

Dependent variables were used in the correlation analyses, as follows: Actual and converted yarn strength for each 14s, 22s, 36s, and 50s yarn; a series of K values of yarn strength representing different ranges of yarn size; and count-strength product of all yarn sizes collectively.

The reported findings show that, as the yarn size decreased over the range of 22s to 50s, upper half mean length increased in importance to yarn strength and fiber strength decreased in importance to yarn strength. As the yarn size diminished over the range of 14s to 22s, however, opposite trends appeared for those two fiber properties.

Fiber fineness increased in importance to yarn strength with decrease in yarn size from 14s to 50s.

The three other quality factors studied (length uniformity ratio, percentage of mature fibers, and grade of cotton) made small contributions to yarn strength and showed no perceptible trends with yarn size.

The evaluated contributions of upper half mean length and fiber strength to strength of each 22s 36s, and 50s yarn appear to be in proper sequence. The evaluated contributions for those two factors to strength of 14s yarn, however, appear to be out of line.

On the basis of averages for the entire series of 277 cottons from the 1948 crop, the relative levels of strength for 14s and 22s yarn are in very close agreement. But, when the values representing differences between converted and actual yarn strength for those samples are stratified, by variety and date of harvesting, various disparities appear in the relative levels of strength for 14s and 22s yarn.

For example, the actual strength of 14s yarn obtained for 24 lots of the Acala 1517 type of cotton was, on the average, 5.0 pounds less than that to be expected on the basis of their actual 22s yarn strength. The differences, moreover, varied appreciably in magnitude with date of harvesting and individual lots of cotton.

For the Coker 100 Wilt cottons, on the other hand, the actual strength of their 14s yarn averaged 2.4 pounds greater than would be expected on the basis of their actual 22s yarn strength. The differences also varied in magnitude with date of harvesting.

The strength level of 14s yarn for the other varieties included showed intermediate differentials between the extremes cited for the Acala 1517 and Coker 100 Wilt cottons.

The occurence of plus and minus differentials in strength of 14s yarn, when the data were stratified by variety and date of harvesting, mathematically explains the excellent over-all agreement in levels of strength for 14s and 22s yarn, representing the entire series of 277 cottons. If the stratification method of approach had not been used in this instance, obviously the plus and minus relations in reference to variety and date of harvesting would have been masked and not realized.

It would appear that the total draft and proportionality of drafts used in processing the 14s yarn, as related to the lower limits of drafts obtainable on the roving and spinning machines employed, influenced the relations under observation. Further, it appears that the effects of those drafting factors forced out of line the expected evaluations for the relative importance of upper half mean length and fiber strength to the strength of 14s yarn, as compared to those with 22s, 36s, and 50s yarn.

What is the explanation for the differentials in reaction of the two extreme varieties, Acala 1517 and Coker 100 Wilt cottons, during the textile processing of their 14s yarn, as compared to their responses in the processing of their 22s and other yarn sizes? The most outstanding fiber property identified with Acala 1517 cotton is high tensile strength. The average fiber strength for the 24 lots of this cotton was 90,400 pounds per square inch, varying by date of harvesting from 92,100 to 87,600. Whether causal or coincidental by association with some other fiber property or factor of fiber structure not considered, the greater the fiber strength the larger was the amount of expected strength of 14s yarn which failed to be realized by the processing organization used in this study.

The fiber strength for the 36 lots of Coker 100 Wilt cotton, on the other hand, averaged 77,300 pounds per square inch, varying by date of harvesting from 78,000 to 76,400. Those values of fiber strength for the Coker 100 Wilt cottons, associated with higher strength of 14s yarn than ordinarily would be expected from the strength of their 22s yarn, are appreciably lower than the fiber strength for the Acala 1517 cottons.

INFLUENCE OF YARN SIZE ON THE RELATIVE CONTRIBUTIONS OF SIX COTTON FIBER PROPERTIES TO STRENGTH OF CARDED YARN

By Robert W. Webb, cotton technologist

INTRODUCTION

Evaluation of the relative importance of measurable cotton fiber properties and other factors of raw-cotton quality to processing performance and product quality is the subject of continuing studies by the Cotton Division of the Agricultural Marketing Service. Such information and related equations derived from these studies are of value to cotton breeders in informing them of the fiber properties they should consider important in their programs, and helpful to the cotton trade and textile industry in choosing cottons best suited to the manufacture of specific products and for meeting various levels of product quality.

From this series of relationship studies on cotton fiber properties, 19 previous reports (13) through (31) 1/ were published. The general problems and objectives involved in these studies, and the benefits expected from the development and application of such information, were discussed in a report by Webb (12) in 1947.

In report (23), Webb and Richardson have shown the relations and relative importance of 6 factors of raw-cotton quality to skein strength of each 22s and 50s carded, warp, long-draft processed, singles yarn representing 828 cottons for 3 crop years, 1945-47. As to the relative contributions of the 6 cotton-quality elements considered for that over-all series of cottons, the factors were found to rank in descending order to strength of 22s and 50s yarn as follows:

Factors of cotton quality	Rank of importance to yarn strength	
	(22s)	(50s)
Fiber strength	1	3
Fiber fineness (wt./in.)	2	1
Upper half mean length	3	2
Length uniformity ratio	4	4
Percentage of mature fibers	5	5
Grade index	6	6

1/ Underscored numbers in parentheses refer to Literature Cited, p. 41.

From the foregoing tabulation, it is evident that fiber fineness (weight per inch) for the 828 cottons from the 3 crop years of 1945-47 was more important to the strength of 50s yarn than to the strength of 22s yarn and that upper half mean length also was more important to the strength of 50s yarn than to the strength of 22s yarn. Fiber strength, on the other hand, was more important to the strength of 22s yarn than to the strength of 50s yarn. The other 3 elements of cotton quality, namely, length uniformity ratio, percentage of mature fibers, and grade index, however, occupied their same ranks of importance to skein strength in the case of both 22s and 50s yarn.

Yarn size influences more particularly the relative contribution of fiber fineness, upper half mean length, and fiber strength to yarn strength. But, when there are shifts in ranks of the importance of those fiber properties to yarn strength representing only two sizes of yarn spaced widely apart, as in the case cited above, it is impossible to know precisely what corresponding evaluations would have been for one or more intervening yarn sizes. Also, it is impossible to know at what yarn size various pairs of fiber properties would make approximately equal contributions to yarn strength. Obviously, the levels and trends of the magnitudes for the contributions of the respective fiber properties to yarn strength, as related to yarn size, would influence and determine such considerations. Those features, no doubt, would vary with cottons representing different varieties and varietal groupings, different growth and seasonal conditions, different processing organizations and efficiencies, different types of yarn construction, and different amounts of yarn twist. The problem is, therefore, more complex than would appear on the surface.

In an effort to answer as many of those questions as possible from the data available, multiple correlation analyses have been made for 6 cotton-quality factors with skein strength of each 14s, 22s, 36s, and 50s yarn, representing a large group of commercial cottons from selected cotton improvement groups, for each of 3 crop years 1948-50. Similar correlation analyses have been completed with collective count-strength product of all yarn sizes processed from each of the 3 series of cottons, for comparative purposes.

Analytical studies of a special nature have been conducted on the 1948 block of data, by variety and date of harvesting, in reference to certain disparities noted for the relative levels in strength identified with the coarsest yarn size studied, and as regards the K factor of yarn strength representing 6 different ranges of yarn size. Supplementing those studies, multiple correlation analyses have been made for the cotton-quality factors in relation to different sets of converted yarn-strength data and to the various series of K values.

Results obtained from all the foregoing analyses are presented and discussed in this report. The new findings reveal definite trends in the relative importance of upper half mean length, fiber strength, and fiber fineness to skein strength of yarns ranging in size from 22s to 50s and conspicuous reversals in the trends of the first two factors mentioned over the yarn size range of 14s to 22s. Evidence has been developed and presented in this report which suggests complicating effects on such comparative evaluations and interpretations by the use of certain combinations of draft and roving size in textile processing, by the presence of limitations in the efficiency of drafting machines when processing a coarse yarn at or near the minimum of their performance range, and by the employment of different rates of card production.

SAMPLES, TESTS, AND DATA

The fiber, spinning, and yarn-strength tests on the cottons used in these analyses were made in the laboratories of the Cotton Division, Agricultural Marketing Service, at Clemson, S. C., and at College Station, Tex.

The fiber and yarn-strength data which served as the basis of this study are contained in publications (8), (9), and (10).

Cottons. All cottons were of the American upland type and they were grown commercially in selected cotton improvement groups across the American Cotton Belt, within their general area of growth adaption, for the 3 crop years of 1948-50. Each variety and location of growth were represented by early-season, mid-season, and late-season samples. The cottons were ginned on commercial saw gins serving the respective cotton improvement groups.

Sampling. Classing samples weighing 4 to 6 ounces were assembled for the most frequently occurring grade and staple-length groups for the respective harvesting periods in each cotton improvement area, until 8 to 10 pounds of raw cotton had been accumulated.

The original grade and staple length designations, which served as the basis for selecting and compositing the comparable lots of cotton for test purposes, were those assigned to the individual samples of raw cotton by USDA cotton specialists. Classification of the samples was made in accordance with the Universal Standards for Grade and the official standards for staple length, as described for American upland cotton in the publication entitled "The Classification of Cotton" (7).

As a result of the method used for selecting the samples, not all of the range of grades and staple lengths appearing in each cotton improvement area was represented by the test cottons.

Processing. Details as to the processing procedure by which the cottons were converted into yarns may be found in the reports setting forth the fiber and spinning test results (8), (9), (10). Report (11) describes the service testing of cotton by the Cotton Division of AMS, including not only processing procedures and waste analyses but also fiber, yarn, and fabric tests.

In brief, all cottons used in this study were processed through the picker and card by the same standard procedure. The cottons for the 2 crop years of 1948 and 1949 were processed at one rate of card production, namely, 9-1/2 pounds per hour; those for the 1950 crop year were carded at one of 3 different rates of production, depending upon the length of the individual cotton. Cottons of 15/16 inch and shorter in staple length were carded at 12-1/2 pounds per hour; those from 31/32 inch through 1-1/16 inches were carded at 9-1/2 pounds per hour; and those from 1-3/32 inch through 1-1/4 inches were carded at 6-1/2 pounds per hour.

The bulk of the 1950 cottons were carded at 9-1/2 pounds per hour and the fact that a small proportion of them was carded at somewhat faster and slower rates of production would not be expected to influence the statistical values obtained from the correlation analyses to any appreciable degree, except as referred to later in this paper in connection with some special comparisons. As shown in report (29), it was found that different rates of card production, ranging even from 2.0 to 15.5 pounds per hour, did not cause the strength of various sizes of carded yarn to vary with any statistical significance.

All yarns from all cottons were processed from long-draft roving by long-draft spinning equipment, represented a warp-type of construction, and possessed a semihard twist. The twist multipliers varied with the upper half mean length of the cottons, the one selected for each cotton being that which gave approximately the maximum yarn strength for an average or typical cotton of the particular classified length. The twist multiplier used in each case, therefore, was not selected to compensate for the influence of other fiber properties involved but represented an empirical selection.

Fiber properties. Six elements of raw-cotton quality were used as independent variables in this study, as follows:

Upper half mean length, in inches, as determined by the Fibrograph method.

Length uniformity ratio, index, as determined by the Fibrograph.

Fiber fineness, in micrograms per inch, as evaluated by the Micronaire method.

Fiber strength, in terms of 1,000 pounds per square inch, as determined by the Pressley tester with the zero gauge.

Percentage of mature fibers, as classified and counted on the basis of 2-to-1 lumen to wall ratio, after they had been permitted to swell in an 18-percent sodium hydroxide solution.

Grade of cotton, expressed as an index.

Grade index was used in this study, as explained in the report of this series having to do with the strength of 22s yarn, regular draft (22). The conversion chart for obtaining grade index values of samples of raw cotton, corresponding to various grade designations originally assigned, was shown in previous reports of this series.

The fiber tests relating to the data used in these analyses were those described in the publication entitled "Cotton Testing Service" (11) and covered more in detail by ASTM Standards on Textile Materials (1).

All fiber tests were made under controlled atmospheric conditions with a temperature of 70°F ± 2° and a relative humidity of 65 percent ± 2 percent according to ASTM specifications (1).

Yarn size. Yarn size, expressed in terms of the generally used or so-called English yarn numbers for cotton, was included as the seventh independent variable in the multiple correlation analyses when, for comparative purposes, count-strength product of all yarn sizes for each crop year was used as the dependent variable.

For the 1948 cottons, 4 sizes of yarn were spun from each sample. All the cottons were spun into 14s, 22s, and 36s yarn. The finest yarn spun from each cotton was either 60s, 50s, or 44s, depending upon the respective staple lengths of the cottons.

For the 1949 cottons, all samples were spun into 14s, 22s, 36s, and 50s yarn.

For the 1950 cottons, either 3 or 4 sizes of yarn were spun from each cotton. All the cottons were processed into 22s and 36s yarn. The finest yarn spun from each sample was either 50s or 36s, and the coarsest yarn processed for each sample was either 22s or 14s, depending upon the respective staple lengths of the cottons.

Yarn strength. Conventional skein-strength tests of all yarns were made, according to the generally adopted procedure described in ASTM Standards on Textile Materials (1) and referred to in Cotton Testing Service (11), and expressed in terms of pounds.

Values for count-strength product were obtained by multiplying the individual yarn strengths by their respective yarn sizes, and expressing the results in terms of count-strength-product units.

All yarn-strength tests were made under the same controlled atmospheric conditions, as specified by ASTM for fiber and yarn testing, namely, a temperature of 70°F. ± 2° and a relative humidity of 65 percent ± 2 percent.

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STATISTICAL ANALYSES

This report covers results obtained from 41 multiple correlation analyses, representing a total of 842 cottons and 3,267 lots of long-draft, carded, warp singles yarn, ranging in size from 14s to 60s, for the 3 crop years 1948-50.

Regular correlation analyses. Using 6 elements of raw-cotton quality, multiple correlation analyses were made with skein strength of each 14s, 22s, 36s, and 50s yarn representing the entire series of cottons for each of the 3 crop years. Also, using the same 6 quality factors and yarn size, a multiple correlation analysis was made with count-strength product, representing all yarn sizes spun from all cottons, for each of the annual series of cottons. Thus, a total of 15 multiple correlation analyses is involved in the regular or conventional phase of this study.

The same general pattern of statistical analyses was followed in this study as that followed in all previous studies of this series. For more detailed information with regard to the statistical terms, measures, and techniques applied, see Appendixes and literature citations in the first and third reports (16), (18).

Beta coefficients and percentage values calculated from them were used to evaluate the relative net contribution or importance of the fiber properties to yarn strength and count-strength product, instead of partial correlation coefficients as was done in the early studies of this series. The reason for the change in method was explained in report (22).

All statistical values reported herein are so-called corrected ones, as obtained from multiple linear correlation analyses. No curvilinear correlation analyses were made in this instance because of the general ranges of cotton-quality factors involved and because previous curvilinear analyses in this series of studies have given no better results with yarn strength than did linear correlation analyses.

Special correlation analyses. Using the same 6 cotton-quality factors, 26 multiple correlation analyses of a supplementary nature have been made in an exploratory effort to gain information bearing on the cause or causes for the observed reversal in trends of importance of fiber length and fiber strength toward yarn strength over the yarn-size range of 14s to 22s, as compared with those for the yarn-size range of 22s to 50s.

Four analyses included dependent variables representing converted yarn strength for the entire series of 1948 cottons, obtained by use of the formula described in report (2), as follows: Strength of 14s yarn converted from strength of 22s yarn, strength of 14s yarn converted from strength of 36s yarn, strength of 22s yarn converted from strength of 14s yarn, and strength of 22s yarn converted from strength of 36s yarn.

Twelve analyses included actual strength of 14s and 22s yarn and converted strength for each yarn size from the other, by variety (Acala 1517, Acala P-18-C, and Coker 100 Wilt) for the 1948 crop year.

Six analyses included dependent variables representing K factors of yarn strength 2/, identified with various ranges of yarn size for the 1948 cottons, as follows: 14s yarn to 22s yarn, 22s yarn to 36s yarn, 36s yarn to finest yarn spun from each cotton, 14s yarn to 36s yarn, 14s yarn to finest yarn spun from each cotton, and average of K values for first 3 ranges of yarn size listed.

Four analyses included dependent variables representing predicted or estimated strength of 14s, 22s, 36s, and 50s yarn processed from the 1948 cottons, as obtained by application of the 1945-47 count-strength-product equation listed in publications (13), (24).

Some necessary conversions of yarn strength for use in regular correlation analyses. The procedure of converting strength of variable yarn sizes identified as the finest processed from the different cottons to strength of a common fine size (50s), as described in this instance, was followed in order to be able to use the same number of cottons, the same range and distribution of fiber properties, and the same range and distribution of yarn strength in the parallel analyses on strength of 14s, 22s, 36s, and 50s yarn, respectively. If this had not been done, obviously the statistical values obtained for the relations and relative importance of the fiber properties to strength of each of the 4 different sizes of yarn would not have been comparable.

For the 1948 cottons, 210 out of the total 277 were spun into 60s as the finest yarn size processed. In those cases, strength of 50s yarn was converted from actual strength of 60s yarn by the formula listed in report (2). In 31 cases, 44s was the finest yarn size spun. In those instances, strength of 50s yarn was converted from actual strength of 44s by the formula cited. Thirty six cases represented actual strength of 50s yarn. As most of the converted strengths of 50s yarn were downward from the strength of 60s yarn actually spun and as only a few were converted upwards from the strength of 44s yarn, obviously no violence was done to the basic data involved. Only actual strength values of yarns spun were included in the analysis with count-strength product used as the dependent variable.

For the 1949 cottons, all samples included in the analyses were spun into 14s, 22s, 36s, and 50s yarn. No conversion of yarn strength, therefore, was necessary in any case.

For the 1950 cottons, 45 samples out of the total 305 were spun into 36s yarn as the finest size processed which necessitated, in those cases, strength of 50s yarn being obtained from actual strength of 36s yarn by the conversion formula referred to in report (2). In 56 cases, the cottons were spun into 22s yarn as the coarsest size processed

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2/ For a discussion of the meaning and limitations of the K factor of yarn strength, see publication by Webb and Richardson (31).

which necessitated in those instances, strength of 14s yarn being converted from actual strength of 22s. All other data used in the analyses represented actual strength of 14s and 50s yarn. Only actual strength values of yarns spun were included in the analysis with count-strength product used as the dependent variable.

INFLUENCE OF YARN SIZE ON THE RELATIONS OF SIX COLLECTIVE COTTON-QUALITY FACTORS TO SKEIN STRENGTH OF CARDED YARN

Values are shown in table 1 3/ for the means, standard deviations, and ranges of data representing the respective independent and dependent variables used in the multiple correlation analyses for each of 3 crop years, 1948-50.

Summarized in table 2 are values for the coefficients of multiple correlation ($\bar{R}$), for the percentages of variance explained in the various dependent variables ($\bar{R}^2$ x 100), and for the standard errors of estimate in the various dependent variables ($\bar{S}$), representing skein strength of each 14s, 22s, 36s, and 50s carded, warp, long-draft singles yarn as well as count-strength product of all yarn sizes spun, for each of 3 crop years, 1948-50.

Referring to table 2 and figure 1, it is apparent that the respective statistical values obtained from multiple correlation analyses for 6 elements of cotton quality and skein strength of each 14s, 22s, 36s, and 50s carded yarn agreed, on the whole, rather closely for all 4 yarn sizes studied. There was a general tendency, however, for the $\bar{R}$, $\bar{R}^2$ x 100, and relative $\bar{S}$ values to increase slightly from the coarsest size of yarn (14s) to the finest size of yarn (50s). The $\bar{R}$ and $\bar{R}^2$ x 100 values obtained with count-strength product for the respective crop years, however, were slightly larger than those identified with the corresponding yarn size giving the largest $\bar{R}$ and $\bar{R}^2$ x 100 values, namely, 50s yarn. It is of interest to note, moreover, that the relative $\bar{S}$ values obtained with count-strength product for each crop year approximated that obtained with strength of 36s yarn for the same year, or the same size that was near the middle of the series.

Crop year 1948. The coefficients of correlation ($\bar{R}$) for the 1948 samples extended from 0.871 with strength of 14s yarn to 0.906 with strength of 50s yarn; the amount of variance in the yarn strength explainable by the 6 cotton quality factors ranged from 75.9 percent with 14s yarn to 82.1 percent with 50s yarn; and the relative standard errors of yarn-strength estimate progressed from ±3.97 percent with 14s

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3/ All tables are grouped in the Appendix at the end of this report and herein after they will be referred to only by table number.

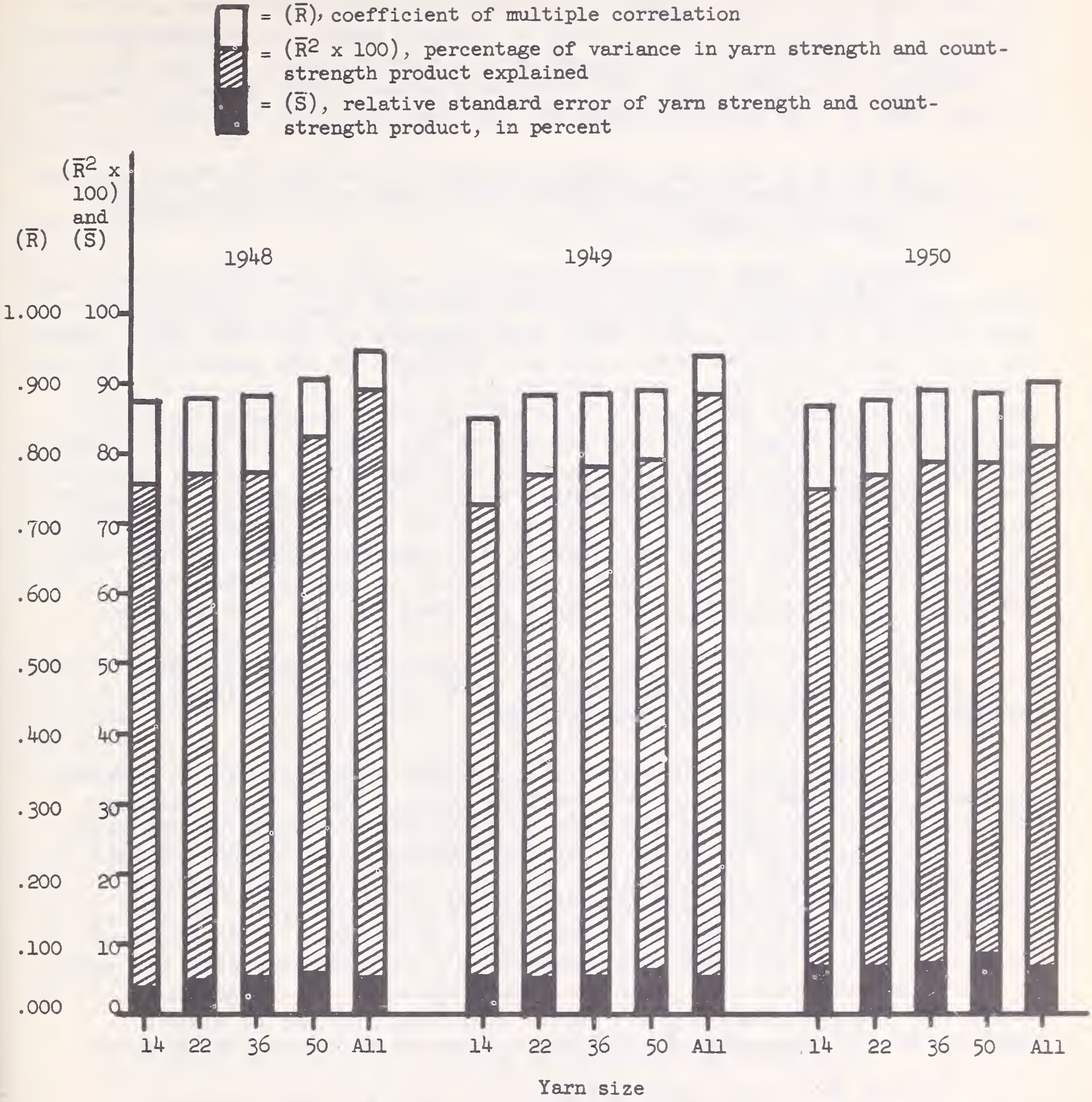

Figure 1.-- The relations of 6 collective quality factors to skein strength of each 14s, 22s, 36s, and 50s carded yarn, and of those factors and yarn size to count-strength product, representing 3 series of American upland cottons, by crop year, 1948-50

yarn to ± 5.93 percent with 50s yarn. Thus, as between the two extremes of yarn sizes covering a range of 36 yarn-size units, there was a difference in $\bar{R}$ value of 0.035 in favor of the 50s yarn; 6.2 percent more variance was explainable in strength of 50s yarn by the 6 factors than in strength of 14s yarn; and the relative standard error of yarn-strength estimate was ± 1.96 percent larger for 50s yarn than for 14s yarn.

The $\bar{R}$, $\bar{R}^2$ x 100, and relative $\bar{S}$ values with count-strength product of all yarn sizes spun from the 1948 cottons were 0.945, 89.3 percent, and ± 5.23 percent, respectively.

Crop year 1949. Similar statistical values were obtained for the fiber-yarn relationships under study for the 1949 season, except that they were on a slightly lower level when compared to that for 1948. That is, the $\bar{R}$ value extended from 0.852 with strength of 14s yarn to 0.890 with strength of 50s yarn, or a difference of 0.038 in favor of the 50s yarn. The amount of variance in yarn strength explainable by the cotton-quality factors ranged from 72.6 percent in the case of 14s yarn to 79.2 percent for 50s yarn, or a difference of 6.6 percent in favor of the 50s yarn. Likewise, the relative standard errors of yarn-strength estimate progressed from ± 5.63 percent with 14s yarn to ± 6.17 percent with 50s yarn. Thus, the relative $\bar{S}$ value was ± 0.54 percent larger for the 50s yarn than for the 14s yarn, a difference which is approximately one-fourth of the corresponding difference reported for the 1948 samples.

The $\bar{R}$, $\bar{R}^2$ x 100, and relative $\bar{S}$ values with count-strength product of all yarn sizes spun from the 1949 cottons were 0.942, 88.7 percent, and ± 5.48 percent, respectively.

Crop year 1950. The correlation values obtained were in general agreement with those for the two previous years. The $\bar{R}$ value extended from 0.870 with strength of 14s yarn to 0.889 with strength of 50s yarn, or a difference of 0.019 in favor of the 50s yarn. The amount of variance in yarn strength accounted for by the 6 cotton quality factors ranged from 75.6 percent with 14s yarn to 79.1 percent with 50s yarn, or a difference of 3.5 percent in favor of the 50s yarn. The relative standard errors of estimate progressed from ± 6.74 percent with 14s yarn to ± 8.47 percent with 50s yarn, or a difference of ± 1.73 percent larger for 50s yarn than for 14s yarn. The $\bar{S}$ difference is almost equal to the corresponding $\bar{S}$ difference obtained with the 1948 samples.

The $\bar{R}$, $\bar{R}^2$ x 100, and $\bar{S}$ values with count-strength product of all yarn sizes spun from the 1950 cottons were 0.904, 81.8 percent, and ± 6.93 percent, respectively.

INFLUENCE OF YARN SIZE ON THE RELATIVE CONTRIBUTIONS OF SIX COTTON-QUALITY FACTORS TO SKEIN STRENGTH OF CARDED YARN

Preliminary Comparisons on the Basis of Beta Values

A comparison of the relative contributions of 6 respective elements of raw-cotton quality to skein strength of each 14s, 22s, 36s, and 50s carded yarn and to count-strength product of all yarn sizes, as based on beta coefficients obtained from the various multiple correlation analyses, is shown in table 3 for the crop year of 1948; in table 4 for 1949; and in table 5 for 1950. Summarized in table 6 are the ranks of importance of the respective fiber properties to strength of each of the 4 sizes of yarn and to count-strength product of all yarn sizes for the 3 crop years.

With 14s yarn. For the 3 respective crop years, upper half mean length ranked first in importance to 14s yarn strength, twice; and third, once. Fiber strength ranked first, once; and second, twice. Fiber fineness ranked second, third, and fourth once each. Grade index ranked third, fourth, and sixth once each. Length uniformity ratio ranked fourth, once; and fifth, twice. Percentage of mature fibers ranked fifth once; and sixth, twice.

With 22s yarn. For the 3 respective crop years, upper half mean length ranked first, second, and third in importance to 22s yarn strength once each. Fiber strength ranked first, twice; and second, once. Fiber fineness ranked second, third and fourth once each. Grade index ranked third, fourth and fifth once each. Length uniformity ratio ranked fourth, once; and fifth, twice. Percentage of mature fibers ranked sixth, three times.

With 36s yarn. For the 3 respective crop years, upper half mean length ranked first in importance to 36s yarn strength, once; and second, twice. Fiber strength ranked first, twice; and second, once. Fiber fineness ranked third, 3 times. Length uniformity ranked fourth, twice; and fifth once. Grade index ranked fourth, fifth, and sixth, once each. Percentage of mature fibers ranked fifth, once; and sixth twice.

With 50s yarn. For the 3 respective crop years, upper half mean length ranked first in importance to 50s yarn strength, 3 times. Fiber fineness ranked second, twice; and third, once. Fiber strength ranked second, once; and third twice. Length uniformity ratio ranked fourth, twice; and fifth, once. Grade index ranked fourth, fifth and sixth, once each. Percentage of mature fibers ranked fifth, once; and sixth, twice.

Final Comparisons in Terms of Adjusted Beta Values

In the earlier part of this section, the relative contributions of 6 cotton-quality elements to strength of each 14s, 22s, 36s, and 50s yarn, as well as to count-strength product of all yarn sizes, were shown by the respective beta coefficients. In this connection, however, it should be understood that, while the beta values are comparable within each analysis representing a particular yarn size and series of cottons, they are not precisely comparable from one analysis to another; that is, from one yarn size to another, or from one series of cottons to another.

In an effort to obtain more comparable measures for the relative contributions of those 6 respective cotton-quality factors to skein strength of the 4 different sizes of yarn, representing the three different series of cottons and the three individual crop years, further calculations based on the beta values have been made. The procedure followed was this: The respective beta values obtained from each multiple correlation analysis was squared, multiplied by 100, and the total interactions and residuals distributed to the various factors in proportion to the amount of variance explained in the dependent variable by each of them.

A comparison of the relative contributions of the respective elements of raw-cotton quality to skein strength of each 14s, 22s, 36s, and 50s carded yarn and to count-strength product of all yarn sizes processed for each of the 3 crop years is shown in table 7. Based on those data, the influence of yarn size on the relative contributions of the respective fiber properties to yarn strength is shown, by crop year and by averages for the 3 crop years, in the graphic charts which follow.

Crop year 1948. Referring to the graphic chart in figure 2 and to the values reported in table 7 for the 277 cottons for the 1948 crop, it will be seen that the relative contribution of fiber fineness (weight per inch) to yarn strength increased appreciably and progressively with decrease in yarn size from 14s to 50s.

Fiber strength decreased sharply in importance to yarn strength with decrease in yarn size from 22s to 50s. The contribution of fiber strength to strength of 14s yarn, however, was less than that to strength of 22s yarn, thus making the trend in contribution of fiber strength over the yarn-size range 14s to 22s opposite to that over the yarn-size range 22s to 50s. On the basis of the results obtained with this series of cottons, interpolation indicates that fiber fineness and fiber strength would have made equal contributions to strength of 40s yarn, if such had been spun.

The relative contribution of upper half mean length to yarn strength increased appreciably with decrease in yarn size from 22s to 50s in the case of the 1948 cottons. The contribution of upper half mean length to strength of 14s yarn, however, was larger than that to strength of 22s yarn. The trend in contribution of upper half mean length to yarn strength over the yarn-size range of 14s to 22s, therefore, was opposite to what it was over the yarn-size range of 22s to 50s.

Length uniformity ratio and grade index each showed approximately the same relative contribution to strength of all yarn sizes. The values for the contributions of those factors to yarn strength were too small to indicate any decernible trends with various yarn sizes. Percentage of mature fibers caused no practical effect on the strength of yarn of any size.

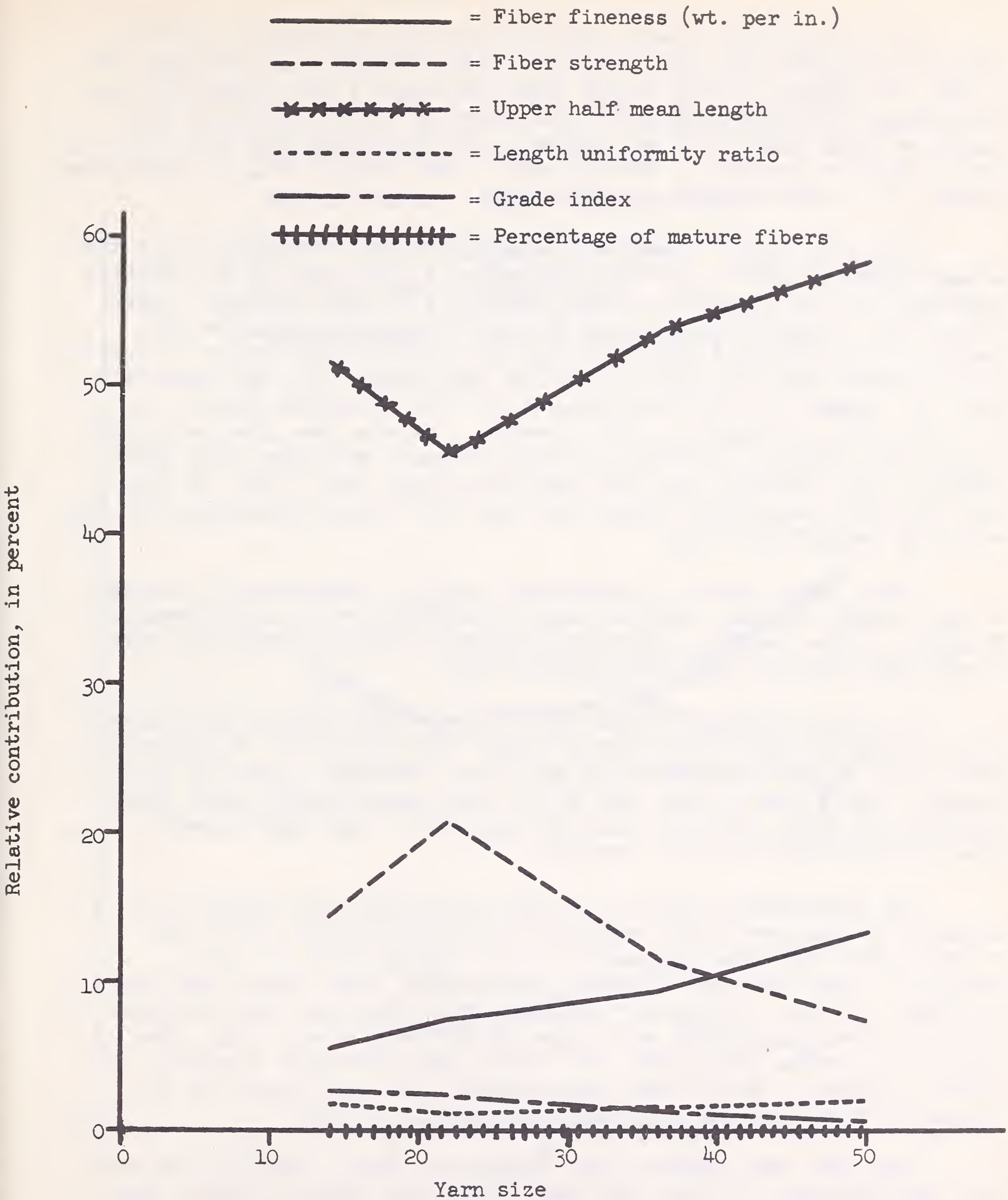

Figure 2.-- The relative contributions of 6 respective cotton-quality factors to skein strength of each 14s, 22s, 36s, and 50s carded yarn, representing 277 American upland cottons, crop year 1948

The inconsistent trends reported for the contribution of fiber strength and upper half mean length to yarn strength over the range 14s to 22s, as compared to the trends noted for those fiber properties with the strength of yarns ranging in size from 22s to 50s, probably were caused in large measure if not entirely, by the roving size and drafting factors used in processing the 14s yarn. That subject will be considered further in a later section of this report.

Crop year 1949. Examining the graphic chart in figure 3 and the values listed in table 7 for the influence of yarn size on the relative importance of the respective fiber properties to yarn strength, representing 260 cottons from the crop of 1949, it will be seen that the trends of the evaluated contributions were similar in a number of particulars to those shown in figure 2 for the 1948 crop. This was especially true with respect to the contributions of fiber fineness (weight per inch) and fiber strength to yarn strength. It also was true as regards inconsistent trends in effects of fiber strength and upper half mean length on yarn strength over the yarn-size range 14s to 22s, as compared with the respective trends for those two fiber properties over the yarn-size range 22s to 50s.

Grade index showed no consistent trend in importance to strength of the 4 sizes of yarn, whereas length uniformity ratio and percentage of mature fibers caused no perceptible effect on the strength of yarn of any size with the 1949 series of cottons.

It is of interest to note that, for the 1949 series of cottons, fiber strength made a considerably larger contribution to strength of yarn of all sizes considered than did fiber fineness. Thus, in this instance, there was no yarn size within the range studied where fiber fineness and fiber strength would be expected to make approximately equal contributions to yarn strength.

The observation referred to above with the 1949 cottons is in contrast to that previously reported for the 1948 group of cottons. In the former instance, the amount of the contribution of fiber strength to yarn strength was on a considerably lower level than that for 1949; in fact, so much so that the trend lines for fiber strength and fiber fineness crossed each other at the yarn size of 40s. (See figure 2.) On the other hand, the trend lines for fiber fineness, as shown in figures 2 and 3, were approximately the same level for the cottons of both the 1948 and 1949 crop years.

The level and course of the respective trend lines for the relative contributions of upper half mean length and fiber strength, however, suggest several interpolations of interest in connection with the 1949 cottons. That is, referring to figure 3, apparently upper half mean length and fiber strength would be expected to make equal contributions to the strength of both 16s yarn and 36.5s yarn. Equal contributions of upper half mean length and fiber strength to yarn strength in the yarn-size zone of 30s to 40s appears entirely logical but that with 16s yarn seems to be illogical in terms of those two fiber properties per se. Rather, the equal contributions to strength of 16s

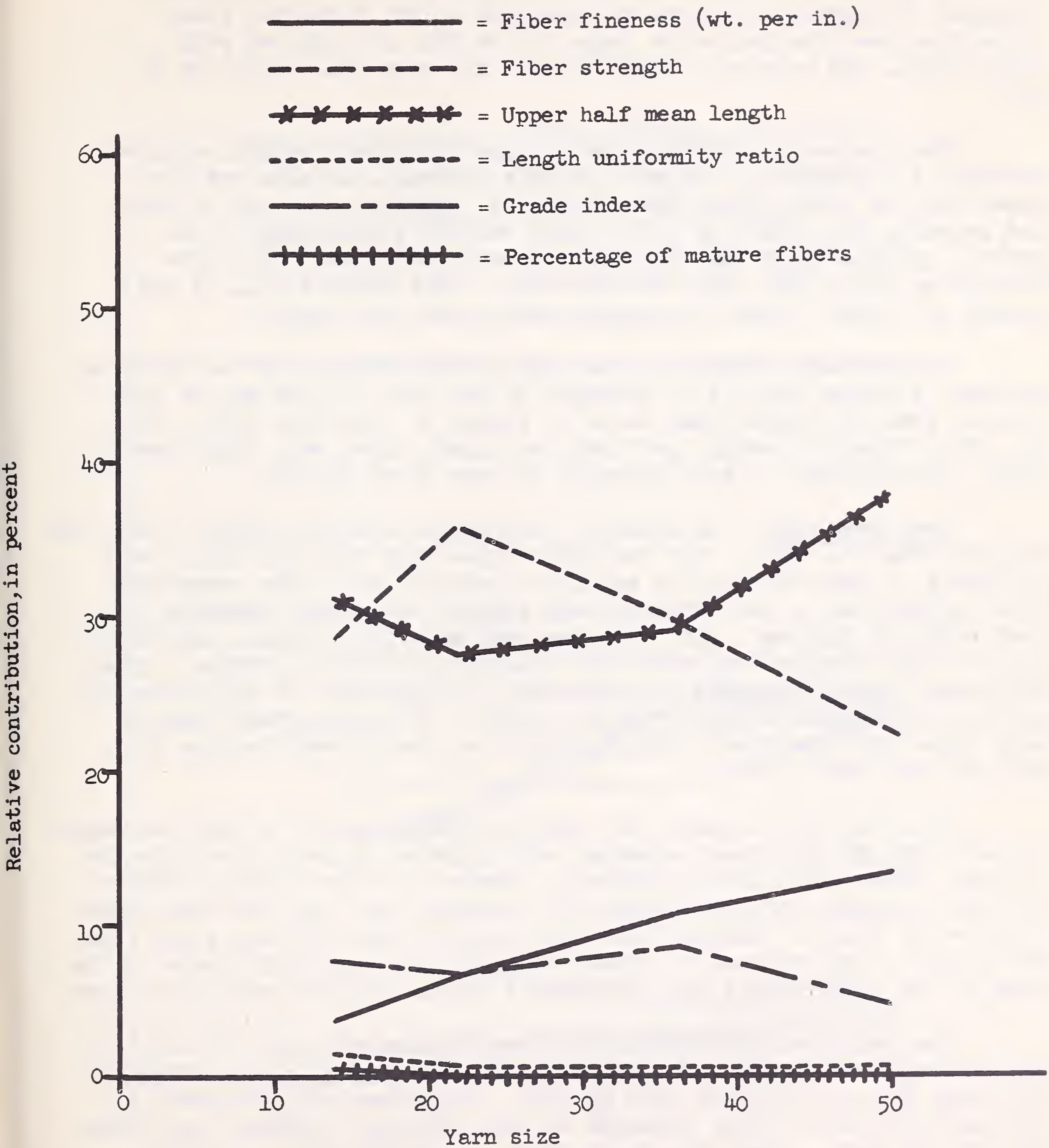

Figure 3.-- The relative contributions of 6 respective cotton-quality factors to skein strength of each 14s, 22s, 36s, and 50s carded yarn, representing 260 American upland cottons, crop year 1949

yarn that have been observed for upper half mean length and fiber strength in this instance would appear to be due to an inadvertent reversal in respective trends of contribution for those two fiber properties over the yarn-size range 14s to 22s, as compared with their normal and expected trends through the yarn size range 22s to 50s.

The evaluated contributions of upper half mean length and fiber strength to strength of 14s yarn in this instance, as also was the case with the 1948 cottons (See figure 2), appears to be out of line and probably the result of one or more variables operating in the textile processing of the 14s yarn that were not operating in the processing of the 22s, 36s, and 50s yarn. This subject will be discussed at further length in a later section of this report.

Another case of more or less equal contributions of two different factors of cotton quality to strength of one size of yarn may be interpolated from the trend lines shown in figure 3, crop year 1949. That is, fiber fineness (weight per inch) and grade index made approximately equal contributions to yarn strength in yarn sizes 22s-24s.

Crop year 1950. As shown by the graphic chart of figure 4 and the values listed in table 7 for the 305 cottons from the 1950 crop, the influence of yarn size on the relative contribution of the respective fiber properties to yarn strength was similar in certain respects to that shown in figures 2 and 3 for the 1948 and 1949 cottons, and different in other details from that with those two series of cottons. Upper half mean length increased progressively in importance to yarn strength as the yarn size decreased from 14s to 50s. No inconsistent results were shown for this fiber property with 14s yarn as was the case with the 1948 and 1949 cottons.

With the 1950 samples, the relative contribution of fiber strength to yarn strength decreased somewhat with decrease in yarn size from 22s to 50s. There was a slight tendency, however, for the trend in effect of fiber strength on yarn strength to increase over the yarn size range from 14s to 22s, as compared with the reverse trend for yarn sizes from 22s to 50s. The reversal in trend, however, was less conspicuous in the case of the 1950 cottons than with the 2 series of 1948 and 1949 cottons.

The relative contribution of fiber fineness (weight per inch) to yarn strength was found to be approximately the same for yarn sizes of 14s, 22s, and 36s with the 1950 cottons. An appreciable increase in the contribution of fiber fineness to yarn strength, however, was noted for the 50s yarn. Thus, the trend line showing the effect of fiber fineness on strength of yarn from 14s to 50s was less steep and less consistent in the case of the 1950 cottons, as compared with that for each of the 1948 and 1949 cottons.

Length uniformity ratio showed a slight decrease in importance to strength of yarns from 14s to 36s in the case of the 1950 cottons but about the same amount for 36s and 50s. This observation is in contrast to that noted for the 1948-49 cottons, where length uniformity

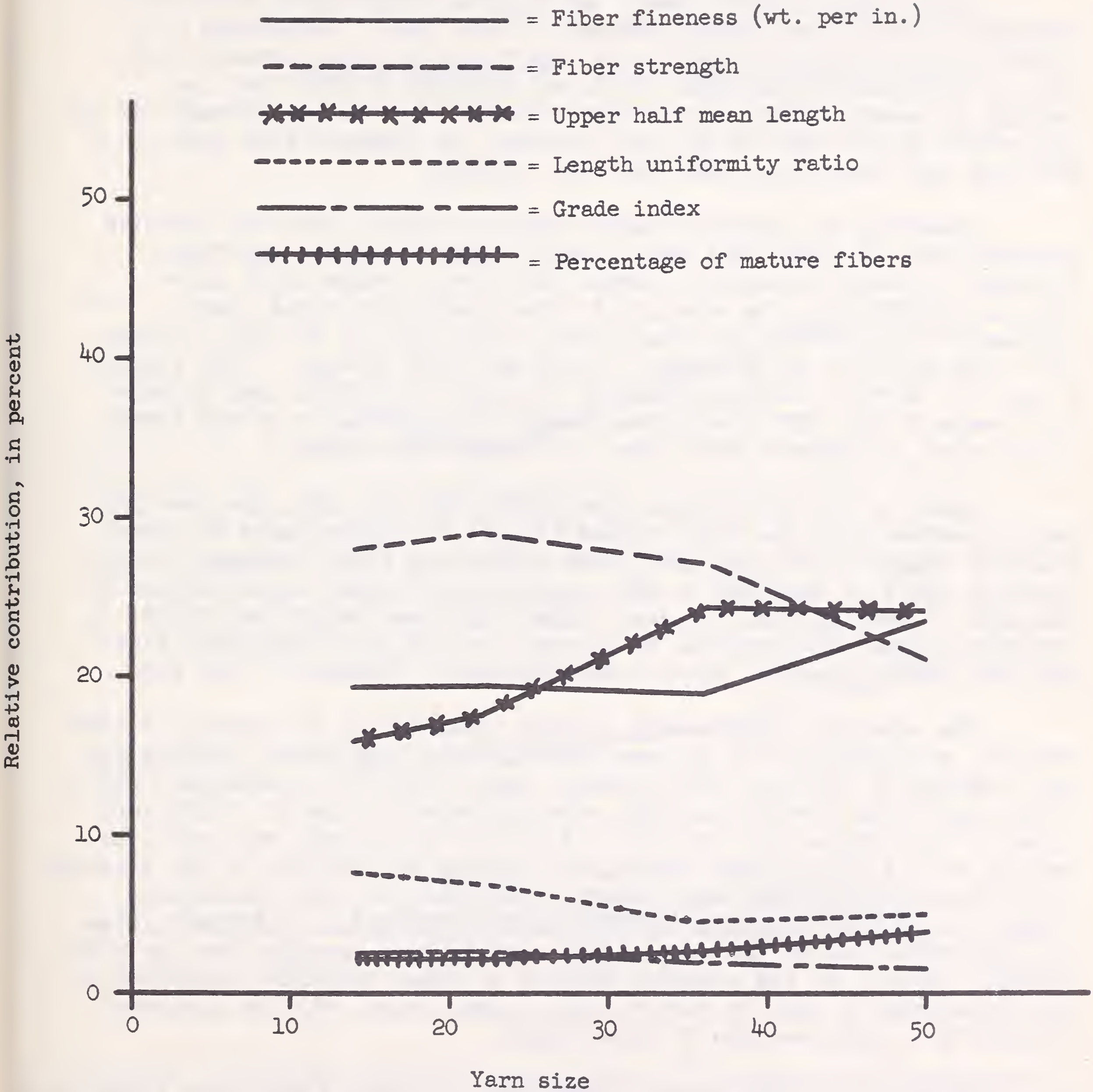

Figure 4.-- The relative contributions of 6 respective cotton-quality factors to skein strength of each 14s, 22s, 36s, and 50s carded yarn, representing 305 American upland cottons, crop year 1950

ratio was found to make only small and about equal contributions to strength of all 4 yarn sizes. The fact that length uniformity ratio made a considerably larger effect on strength of yarn of all sizes with the 1950 cottons than it did with the 1948 and 1949 cottons is of interest.

Grade index showed a small and slightly diminishing effect on strength of yarn from 14s and 22s yarn to 50s yarn. Percentage of mature fibers increased slightly in importance to yarn strength from 14s and 22s yarn to 50s yarn. It is of interest to note that percentage of mature fibers contributed somewhat more to the strength of all yarn sizes in the case of the 1950 cottons, as compared with what it did with the 2 series of 1948 and 1949 cottons.

Examining the graphic charts shown in figure 4 for the relative contributions of upper half mean length, fiber fineness, and fiber strength to skein strength of carded yarn over a range of 36 units (14s to 50s), it will be noted that those respective trend lines represented more nearly the same level in the case of the 1950 cottons than they did with the 2 series of 1948 and 1949 cottons. (See figures 2 and 3.) Several interpolations of interest, therefore, may be made on a basis of the 1950 evaluations where different pairs of the trend lines cross or approach each other at certain yarn sizes.

Based on the evaluations identified with 14s, 22s, 36s, and 50s yarn processed from the 1950 cottons (figure 4), comparisons by interpolation suggest that upper half mean length and fiber fineness in this instance would be expected to make approximately equal contributions to strength of both 25s and 50s yarn; upper half mean length and fiber strength, equal contributions to strength of 43s yarn; and fiber fineness and fiber strength, equal contributions to strength of 47s yarn.

The somewhat inconsistent results obtained for the series of 1950 cottons, as compared with the more definite and consistent findings for the 2 series of 1948 and 1949 cottons, may be due--in considerable part--to the fact that the 1950 cottons were processed at one of 3 different rates of card production (12-1/2, 9-1/2, or 6-1/2 pounds per hour), as related to 3 staple-length categories, whereas all cottons in the 2 series of 1948 and 1949 cottons were carded at one rate of card production, namely, 9-1/2 pounds per hour. The possible effects of different rates of card production on the correlation results here reported for the 1950 cottons, as well as the possible effects of other variables operating in the processing of the 14s yarn for all 3 crop years, will be discussed further in a later section of this report.

Average of 3 crop years. Summarized in table 8 and shown graphically in figure 5 are the average relative contributions of 6 factors of cotton quality to skein strength of each 14s, 22s, 36s, and 50s yarn, representing 842 cottons, 3,267 lots of yarn, and crop years 1948-50.

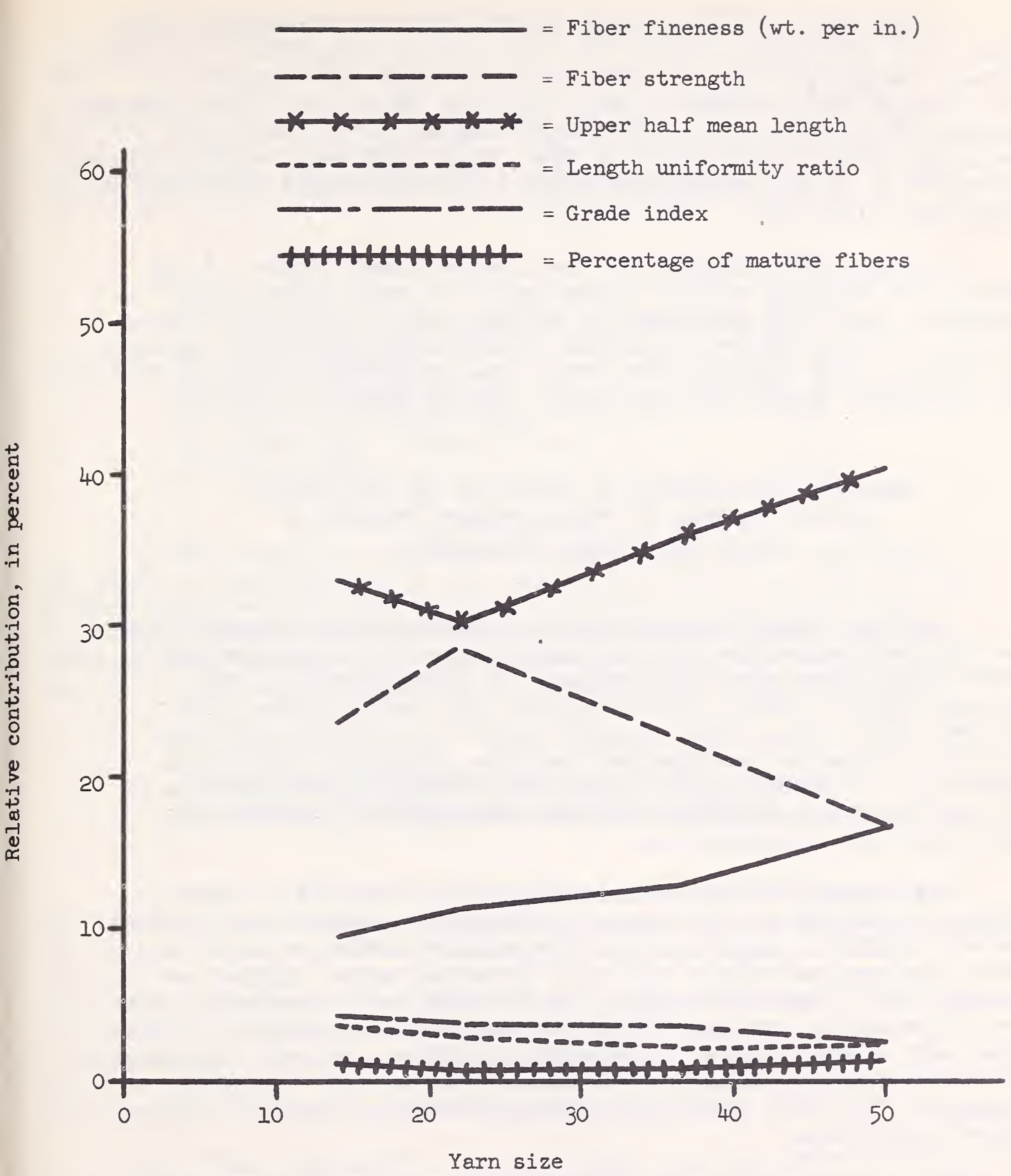

Figure 5.-- Average relative contributions of 6 respective cotton-quality factors to skein strength of each 14s, 22s, 36s, and 50s carded yarn, representing 842 American upland cottons, crop years 1948-50

On the basis of the averages obtained for the 3 respective crop years, it is strikingly evident that the relative contribution of fiber fineness (weight per inch) progressively increased in importance to yarn strength with decrease in yarn size from 14s to 50s. Fiber strength decreased in importance to yarn strength from 22s to 50s but showed a reversal in this trend from 14s to 22s. Upper half mean length increased in importance to yarn strength from 22s to 50s but showed a reversal in trend from 14s to 22s.

Averages of the values for the 3 years showed little, if any, variation or trend in relative contribution of grade index, length uniformity ratio, and percentage of mature fibers to strength of yarn of various sizes. Slight tendencies of trends and reversals, however, were noted in some instances for those fiber properties, when the findings were considered by separate crop years. (See figures 2, 3, and 4.)

RELATIVE CONTRIBUTION OF YARN SIZE AND SIX COTTON-QUALITY FACTORS TO COUNT-STRENGTH PRODUCT OF ALL YARN SIZES COLLECTIVELY

The beta values representing the relative contribution of yarn size and the 6 respective cotton-quality factors to count-strength product of all yarn sizes collectively are shown in table 3 for crop year 1948, in table 4 for crop year 1949, and in table 5 for crop year 1950. When count-strength product of all yarn sizes collectively is used as the dependent variable, obviously there is no opportunity for evaluating the trend of the relative contributions of the respective cotton-quality factors to strength of the individual yarn sizes under consideration.

The average relative contributions of the factors to count-strength product of all yarn sizes collectively, nevertheless, possess interest by way of comparison with the relative contributions of the factors to strength of yarn for the 4 individual sizes studied, as presented in the previous chapter. When making such comparisons, however, it should be remembered that the analyses with strength of individual yarn sizes included 6 independent variables, whereas the analyses with count-strength product of all yarn sizes included 7 independent variables. The extra factor in connection with the latter, of course, refers to yarn size.

Considering all yarn sizes collectively for the 3 respective crop years, as shown by tables 3, 4, and 5 and as summarized in table 6, it is evident that yarn size ranked first in importance to count-strength product in all three cases. Upper half mean length ranked second, twice; and fourth, once. Fiber strength ranked second, once; and third, twice. Fiber fineness ranked third, once; and fourth, twice. Grade index, length uniformity ratio, and percentage of mature fibers each ranked fifth, sixth and seventh, once.

The adjusted beta values for showing more comparable relative contributions of yarn size and of the 6 respective cotton-quality factors to count-strength product of all yarn sizes collectively are shown, by crop year, in table 7. The over-all averages of those adjusted beta values, representing 842 cottons, 3,267 lots of yarn, and 3 crop years, are summarized in table 8. The respective factors made average relative contributions to count-strength product of all yarn sizes collectively for 3 crop years combined, as follows:

Factors	Percent
(1) Yarn size	49.72
(2) Upper half mean length	16.60
(3) Fiber strength	10.34
(4) Fiber fineness (wt./in.)	6.11
(5) Length uniformity ratio	1.71
(6) Percentage of mature fibers	1.12
(7) Grade index	1.00

As may be seen by reference to table 7, the values represent the relative contributions of the respective factors to count-strength product varied more or less for the 3 individual crop years. This naturally follows in the light of the variable correlation findings obtained with strength of the individual yarn sizes for the respective crop years, as presented in the previous section of this report.

COMPARISON OF CONVERTED AND ACTUAL YARN-STRENGTH VALUES, BY VARIETY AND DATE OF HARVESTING

As shown in figure 2 for the 1948 cottons and in figure 3 for the 1949 cottons, noticeable reversals occurred in the respective trends for the relative contributions of upper half mean length and fiber strength to strength of yarn over the range 14s to 22s, as compared with their respective trends over the yarn size range 22s to 50s. The reported trends for the contributions of those two cotton-quality factors to yarn strength from 22s to 50s were naturally to be expected. The opposite trends reported for those factors to yarn strength from 14s to 22s were not expected; in fact, they were surprising.

All things considered it would appear that the evaluated contributions of upper half mean length and fiber strength to strength of 22s, 36s, and 50s yarn are in proper sequence but that the evaluated contributions for those two factors to strength of 14s yarn are out of line. Further evidence of different types, however, is needed for assistance in determining whether the values cited for 14s yarn are out of line; if so, how much, and whether there is anything unusual about or peculiar to the 14s yarn used in this study, as compared with the 3 other related yarn sizes included.

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In an effort to find the cause or causes for the apparently inconsistent findings obtained with the 14s yarn, some special and supplementary analyses were made of the fiber and yarn-strength data, representing 277 cottons from the 1948 crop, that went into the multiple correlation analyses. The basic fiber and yarn-strength data for the 1948 cottons, stratified by variety and date of harvesting, are presented in table 9. Presentation of the fiber data in that form is of interest to a consideration of the results which follow in this section and subsequent sections of this report.

Using the formula reported in publication (2) for converting strength of a particular yarn size to that of another, strength of 14s yarn was converted from actual strength of 22s yarn for each of the 277 cottons, crop year 1948; strength of 14s yarn was converted from actual strength of 36s yarn for each of those cottons; strength of 22s yarn was converted from actual strength of 14s yarn, in each case; and strength of 22s yarn was converted from actual strength of 36s yarn for all 1948 cottons. Absolute and relative values representing differences between the corresponding converted and actual yarn-strength data for the 1948 cottons, stratified by variety and date of harvesting, are summarized in table 10.

Referring to table 10, it will be seen that, on the average for the 277 cottons, the relative levels of strength for the series of 14s yarn and for the corresponding series of 22s yarn were on a par. The over-all difference between strength of 14s yarn converted from strength of 22s yarn and actual strength of 14s yarn was only - 0.3 pound. That is, on the average for the 277 cottons from the 1948 crop, the strength of 14s yarn converted from strength of 22s yarn was only 0.3 pound or 0.2 percent less than the actual strength for the entire series of 14s yarn. Thus, on the basis of averages for the complete series of 1948 cottons considered as a whole, the levels of strength for 14s and 22s yarn were in excellent agreement.

But, when the values representing differences between converted and actual yarn strength were stratified, by variety and date of harvesting, various disparities appeared in the relative levels of strength for 14s and 22s yarn and some of them were comparatively large. Moreover, the direction of those differences was not always the same; that is, some were plus and others were minus. Several examples will be cited for purposes of illustration but the other possible ones may be seen by study of all the data presented in table 10.

More particularly, by reference to table 10, the 24 lots of the Acala 1517 type of cotton showed their strength of 14s yarn converted from their actual strength of 22s yarn to be, on the average, 5.0 pounds larger than their actual strength of 14s yarn. In other words, the actual strength of 14s yarn obtained for the 24 lots of the Acala 1517 type of cotton was, on the average, 5.0 pounds smaller than that to be expected on the basis of their 22s yarn strength. The average difference between strength of 14s yarn converted from actual strength of 22s yarn and actual strength of 14s yarn, representing 8 respective lots of the Acala 1517 type of cotton by date of harvesting were, as follows: Early samples, + 6.9 pounds; Midseason, + 5.9 pounds; and late + 2.1 pounds. The differences for individual lots of cotton were, in many cases, appreciably larger than the differences reported for the 3 different groups of 8 individual cottons of the Acala 1517 type.

Thus, it would appear that the strength of the 14s yarn obtained for the 24 lots of Acala 1517 type of cotton was, in most instances, appreciably lower than that which properly might be expected from the level of strength for their 22s yarn. What is the explanation for this? The most outstanding and unusual fiber property identified with Acala 1517 cotton, as shown by table 9, is fiber strength. The average fiber strength for the 24 lots of Acala 1517 cotton was 90,400 pounds per square inch. For the different dates of harvesting, the average fiber strength for the respective 8 lots of Acala 1517 cotton were, as follows: Early season, 92,100 pounds per square inch; Midseason, 91,500 pounds; and late, 87,600 pounds. It is of interest to note, whether merely coincidental or causal in effect, that the greater the fiber strength the larger was the amount of expected strength of 14s yarn which failed to be realized by the processing organization used.

Turning to another case in the reverse direction, attention is directed to the findings reported in table 10 for the 36 lots of Coker 100 Wilt cottons. The average difference between strength of 14s yarn converted from strength of 22s yarn and actual strength of 14s yarn for this variety was 2.4 pounds. In other words, the average strength of 14s yarn processed from the Coker 100 Wilt cottons was 2.4 pounds larger than would be expected from their average strength of 22s yarn. The average difference between strength of 14s yarn converted from strength of 22s yarn and actual strength of 14s yarn was largest for the 14 early season samples of Coker 100 Wilt, followed by diminishing average differences for the 11 cottons of this variety representing the 2 later dates of harvesting, as revealed by the following respective values: Early samples, - 3.7 pounds; midseason, - 2.4 pounds; and late, - 0.7 pound. Difference values for some of the individual lots of Coker 100 Wilt cotton were, of course, larger than the 3 average difference values cited.

On the basis of the foregoing, it would appear that the strength of the 14s yarn obtained for the 36 lots of Coker 100 Wilt cotton was, in most cases, appreciably higher than that which normally might be expected from the level of strength for their 22s yarn. The fiber strength averaged 77,300 pounds per square inch for the Coker 100 Wilt cottons used in this study and the averages for the 3 respective dates of harvesting were as follows: Early samples, 77,400 pounds; midseason, 78,000 pounds; and late, 76,400 pounds. These values of fiber strength for the samples of Coker 100 Wilt cotton, associated with higher strength of 14s yarn than ordinarily would be expected from the strength of their 22s yarn, are appreciably lower than the fiber strength values for the 24 samples of the Acala 1517 type of cotton previously referred to, where substantially lower yarn strength of 14s yarn was obtained than normally would be expected from the strength of their 22s yarn.

Whether the large differences between fiber strength reported in table 9 for the Acala 1517 and Coker 100 Wilt cottons are responsible for the opposite levels found for their respective strengths of 14s yarn, as compared with their respective strengths of 22s yarn, cannot be foretold by the data available at this time. All things considered, however, it would appear that fiber strength, in connection with the drafting process used in the manufacture of these lots of 14s yarn, probably was a factor influencing in some direct or indirect manner the differentials reported for strength of 14s yarn, as compared with their corresponding strengths of 22s yarn. How much the factor of cotton fiber strength may have contributed in this way is, of course, problematical at the present time.

Between the 2 extreme cases cited for the lots of Acala 1517 and Coker 100 Wilt cottons, intermediate values for the differentials in strength of 14s yarn--in relation to their respective strengths of 22s yarn--were obtained for the other cottons studied by variety and date of harvesting, as may be seen by reference to table 10. The fiber properties identified with the other cottons also are shown in table 9.

The occurrence of plus and minus differentials in strength of 14s yarn as compared to corresponding strength of 22s yarn, when stratified by variety and date of harvesting, explains the excellent over-all agreement in levels of strength reported in table 10 for 14s and 22s yarn, representing the entire series of 277 cottons for the crop year 1948. This finding emphasizes the danger to be encountered by making such studies of cotton-quality-processing problems in terms of averages and without grouping the basic data by variety, date of harvesting, or some other method of segregation. If the stratification method of approach had not been used in this instance, the plus and minus relations would have been masked and not realized; and the reported differentials in level of strength for the 14s yarn representing the various varieties and dates of harvesting would not--and could not--have been revealed.

COMPARISON OF K FACTORS OF YARN STRENGTH REPRESENTING SIX RANGES OF YARN SIZE, BY VARIETY AND DATE OF HARVESTING

In an effort to obtain further information on the comparative levels of strength for the 14s and 22s yarn used in the study covered by this report, another method of approach was used which is different, in certain considerations, to the so-called converted-yarn-strength method whose results were presented and discussed in the previous section of this report. The former method used the improved conversion formula reported by Campbell in 1936 through publication (2), the formula of which represented the average relations involved in 425 American upland cottons spun in the laboratories of the Cotton Division prior to 1936, and representing more than 70,000 skein-strength tests of yarn over a wide range of sizes. All yarns used in that study represented regular-draft processing.

Yarn-size factor of yarn strength. The average slope formed by the various curves developed from the study referred to above, representing various large groups of cotton segregated by staple length, was found to be such that 1 unit of yarn size, or 1 count unit, was equivalent to 21.7 count-strength-product units. The values of the constants used in the over-all conversion formula, however, varied progressively from 25.1 with cottons of 13/16 inch staple length to 15.9 with cottons of 1-1/4 inches in staple length.

As reported by Webb and Richardson in publication (24), they found the yarn-size factor in their count-strength-product equation for crop years 1945-47, representing 828 American upland cottons and 2,484 lots of yarn ranging from 14s to 60s, to be 18.0. Seventy percent of the cottons included in that study was obtained from the Experiment Station Annual Variety Test Series and 30 percent represented commercial cottons from selected cotton improvement groups. Ninety percent of those cottons represented early picked samples; 10 percent, midseason; and no samples were included for late-season harvesting. All yarns used in that study represented long-draft processing.

Referring to publication (13) issued by Webb in 1954, it will be seen that the yarn size factor for the 8 crop years 1945-52 varied from 16.9 for the 1950 crop to 19.5 for the 1949 crop. The average yarn-size factor for 8 crop years, representing 2,298 American upland cottons and 7,007 lots of yarn ranging in size from 14s to 60s, calculated to be 18.1. This study included the cottons of 1945-47, as referred to above, and also all tested commercial cottons from selected cotton improvement groups for 3 dates of harvesting over the 5 year period 1948-52. All yarns used in that study represented long-draft processing.

The yarn-size factor in the most recent count-strength-product equation reported by Webb through publication (14) was 17.6 for 842 American upland cottons grown in approximately 100 selected cotton improvement groups across the U. S. cotton belt, for each of 3 crop years 1948-50. Those analyses involved a total of 3,267 lots of yarn, ranging in sizes from 14s to 60s, and representing the principal varieties in current production as well as 3 dates of harvesting in all cases (early, midseason, and late). All yarns used in that study represented long-draft processing.

In view of the fact that the value of the yarn size factor varies considerably for different groups of cottons and crop years, and more particularly with individual cottons representing different staple lengths and combinations of fiber properties, it was considered advisable to evaluate directly the relative levels of strength of 14s and 22s yarn processed from the 1948 series of cottons, which are under particular study in this instance, on the basis of the so-called K factor of yarn strength representing each of the 277 individual cottons involved.

K factor of yarn strength. By definition, the K value of yarn strength for a cotton generally represents the average decrease in count-strength-product units (break factor) per unit increase in yarn number, as based on the actual strength of two widely different yarn sizes spun from the same cotton. Such K values are derived by a simple mathematical process; that is, the subtraction of the count-strength product of a fine size of yarn from the count-strength product of a coarse size of yarn processed from the same cotton with the same yarn-twist multiplier, and dividing the difference obtained by the number of intervening yarn sizes involved. Thus, K values are expressed in terms of count-strength-product units and are comparable with the over-all values for the yarn-size factor previously considered, as obtained from multiple correlation analyses with count-strength product used as the dependent variable (24), (13), and (14).

For the purpose of this special study, 6 K factors of yarn strength, representing 6 different ranges of yarn size, were calculated for each of the 277 cottons included in the 1948 series. A description of the various K values obtained for the individual cottons is, as follows:

(1) K factor for strength of 14s to 22s yarn
(2) K factor for strength of 22s to 36s yarn
(3) K factor for strength of 36s to finest yarn spun
(4) K factor for strength of 14s to 36s yarn
(5) K factor for strength of 14s to finest yarn spun
(6) K factor of yarn strength, average of (1), (2), and (3)

A comparison of the values for the 6 respective K values of yarn strength for the 277 cottons from the 1948 crop, listed by variety and date of harvesting, is shown in table 11. It will be noted that the over-all average K value for the yarn-size range 36s to the finest yarn size spun from each cotton, representing the entire series of cottons, was 14.0. The average K values for the respective varieties were remarkably consistent, extending only from 13.1 for the Coker 100 Wilt cottons to 15.6 for the Acala 1517 cottons and the average K values within variety, by date of harvesting, were notably consistent. These findings indicate that the relative levels of strength for 36s yarn and the finest yarn processed from each cotton were, in all cases, on a par and those which properly might be expected from the processing organization used in manufacturing those yarns.

The K values shown in table 11 for the yarn size range 22s to 36s also were relatively consistent for the respective varieties, except for the Rowden cottons, the latter of which is explainable. The over-all average K value for this yarn-size range, representing the entire series of 277 cottons, was 20.4 and the average K values for the respective varieties, other than for Rowden, were reasonably consistent. Excluding the Rowden variety, the average K values for the remaining 5 varieties ranged from 16.8 for the Coker Wilt variety to 21.8 for the Acala P-18-C variety and the average K values within variety, by date of harvesting, fluctuated slightly but not unduly.

In the case of the Rowden variety, the average K value for the yarn-size range 22s to 36s was 28.1 and the average K value, by date of harvesting, extended from 26.9 to 29.4 (See table 11.) Those K values are comparatively large, as compared with the corresponding K values for the other varieties, and are explainable by the fact that the Rowden cottons possess such relatively short and coarse fibers. That is, because of those fiber properties, the strength of 36s yarn processed from the Rowden variety, as related to its strength of 22s yarn, decreased to a larger degree than did other varieties with longer and finer fibers.

On the whole, therefore, the K values for the various varieties studied separately over the yarn-size range 22s to 36s indicate that the relative levels of strength for those two yarn sizes were, in all cases, on a par and those which naturally might be expected. Thus, in the light of all the K values referred to so far, it would appear that the strength values for the respective yarn sizes of 22s, 36s, and the finest yarn spun from each cotton (44s, 50s, or 60s), when considered by variety, date of harvesting, and as a whole, were on relatively comparable levels and those to be anticipated.

But, upon examining the respective K values for the yarn-size range 14s to 22s shown in table 11, it will be seen that they fluctuate more widely than do corresponding ones for the yarn-size ranges 22s to 36s and 36s to the finest yarn processed from each cotton, due regard being given to the limiting factor of staple length in the case of the extremely short, coarse-fibered Rowden cottons. More particularly, the average K value of yarn strength for the 24 lots of Acala 1517 type of cotton was 13.0 and the average K values, by date of harvesting, were as follows: Early, 9.7; midseason, 11.4; and late 17.8. The average K value for the 36 lots of Coker 100 Wilt cotton was 25.9 and the average K values for 3 successive dates of harvesting were 28.2, 25.6 and 23.4. Corresponding K values for the other varieties generally were intermediate between the extremes cited for the Acala 1517 and Coker 100 Wilt varieties.

Also, it is evident that the fluctuations in K values for the yarn-size range 14s to 22s are in line with the corresponding fluctuations in difference values between strength of 14s yarn converted from 22s and actual strength of 14s yarn, as reported in table 10 by variety and date of harvesting, and as covered in the previous section. It is evident, moreover, that those K values give strong support to the conclusions drawn in the previous chapter with respect to the variable and uncomparable level of 14s yarn strength from this series of cottons, as compared with their respective strength values for 22s yarn. That is, the new evidence supplied directly by the K values of yarn strength identified with the respective pairs of yarn sizes give proof that the actual strength of 14s yarn for Acala 1517 cottons was unduly low; that the actual strength of 14s yarn for the Coker 100 Wilt cottons was unduly high; and that the actual strength of 14s yarn for the other 4 varieties was out of line but to a lesser degree than in the extreme cases observed in opposite direction, for the Acala 1517 and Coker 100 Wilt cottons.

As pointed out in the previous section of this report, the most outstanding difference in fiber properties between the two extreme varieties, Acala 1517 and Coker 100 Wilt, is fiber strength. The average fiber strength of the 24 lots of Acala 1517 cotton from the 1948 crop was 90,400 pounds per square inch, and that for the 36 lots of Coker 100 Wilt cotton was 77,300 pounds per square inch, or a difference of 13,100 psi in level of fiber strength. Obviously, this is a large difference in fiber strength. Whether the high fiber strength of the Acala 1517 cottons influenced the drafting of their fibers in the textile processing used in this instance for manufacturing 14s yarn and, thereby, caused the strength of their 14s yarn to be relatively low, as compared with the strength of their 22s yarn and that of their other yarn sizes, is problematical. Likewise, whether the low fiber strength of the Coker 100 Wilt cottons influenced the drafting of their fibers in the textile processing used for manufacturing 14s yarn and, thereby, caused the strength of their 14s yarn to be comparatively high is problematical.

But, on the basis of the observations made in this study and presented in this report, fiber strength is suggestive as being the factor causing, directly or indirectly, the relatively low and out-of-line strength of 14s yarn for the Acala 1517 cottons and the comparatively high and out-of-line strength of 14s yarn for the Coker 100 Wilt cottons. It could be, of course, not fiber strength but some one or more fiber properties or other factors of cotton quality, which have not been considered here but which may be highly correlated with different levels and variations of fiber strength. Whatever it may be, there was something operating in the drafting of those cottons into 14s yarn, which influenced the behavior of their fibers during processing, created a differential in drafting efficiency, and caused a differential effect on yarn strength. Further experimental studies of a special and comprehensive nature, however, are required to provide the data needed to answer those questions and to solve this problem, whereby the production of highly comparable yarns of all sizes, particularly over the coarse range, can be guaranteed for research purposes.

Comparison of values for K factor and yarn-size factor. Separate and aside from the issue of relative levels of strength for the 14s and 22s yarn from the 1948, 1949, and 1950 cottons, it is of interest to compare certain average K values shown in table 11 with the average values reported previously for the yarn-size factor representing large series of cottons, wide ranges of fiber properties, and different crop years. It will be noted that the over-all K value for the entire 277 cottons from the 1948 crop, representing all yarn sizes from 14s to 60s, was 17.9. That K value is essentially the same as the average value of 18.0 reported by Webb and Richardson (24) for the yarn size factor in the count-strength-product equation, representing 828 American upland cottons and 2,484 lots of yarn ranging from 14s to 60s, for the 3 crop years of 1945-47. The new over-all K value of 17.9 for the 1948 crop is essentially the same as the average value of 18.1 reported by Webb (13) for the yarn size factor, representing 2,298 American upland cottons and 7,007 lots of yarn ranging from 14s to 60s, for the 8 crop years of 1945-52. The new over-all K value of 17.9 for the 1948 crop is approximately the same as the average value of 17.6 reported by Webb (14), representing 842 American upland cottons and 3,267 lots of yarn from 14s to 60s, for the 3 crop years of 1948-50.

The new over-all K value of 17.9 reported in table 11 of this report for the 1948 samples and the other ones cited above from previous studies and publications (24), (13), and (14) are somewhat smaller than the average value of 21.7 reported by Campbell (2) for the average yarn size factor, representing 425 American upland cottons and more than 70,000 skein-strength tests of yarn over a wide range of sizes. The new value, however, is within the progressive series of values from 25.1 with cottons of 13/16 inch in staple length to 15.9 with cottons of 1-1/4 inches in staple length as reported by Campbell (2).

In this connection, it must be remembered that the values reported by Campbell (2) are identified with cottons obtained from various Experiment Station Annual Variety Test Series for a number of crop years prior to 1936 and with yarns representing regular draft processing. Over the intervening 19 years, obviously many changes have been made in the varieties grown and, through plant breeding, many far reaching changes have been made in the combinations of fiber properties present in the more or less standard varieties of former years.

As a result, therefore, the varietal and fiber-property situation in commercial cottons during the last few crop years, with which the findings of Webb et al have been identified, were different from those existing 15 or more years ago. Moreover, the results reported by Webb et al for the last 10 crop years have represented long-draft processing, whereas those of earlier dates represented regular-draft processing. Such variations in results as reported over the years in this instance, therefore, are not surprising; in fact, they are to be expected and, in most cases, they are understandable.

COMPARISON OF STATISTICAL VALUES OBTAINED FROM SUPPLEMENTARY ANALYSES

In an effort to obtain further information on the fact that the strength of 14s yarn was out of line with the strength of 22s yarn, and that the respective trends in contributions of upper half mean length and fiber strength to strength of yarn reversed themselves over certain parts of the yarn-size range, some special and supplementary analyses were made on the data representing 277 cottons, crop year 1948. Those multiple correlation analyses included the usual 6 factors of cotton quality as independent variables. Used as dependent variables were 4 series of values for converted yarn strength, 6 series of K values representing 6 different ranges of yarn size, and 4 series of values for estimated yarn strength representing 4 yarn sizes. The nature and scope of the data used in those analyses are revealed by the values listed in table 12.

Converted Yarn Strength Used as Dependent Variables

Table 13 shows a comparison of the $\bar{R}$, $\bar{R}^2$ x 100, the absolute $\bar{S}$, the relative $\bar{S}$, and the beta values for the analyses with actual strength of 14s and 22s yarn and with respective converted yarn strength values, for the 277 cottons from the 1948 crop, as follows:

Strength of 14s yarn converted from strength of 22s
Strength of 14s yarn converted from strength of 36s
Strength of 22s yarn converted from strength of 14s
Strength of 22s yarn converted from strength of 36s

The multiple correlation values obtained from the 6 analyses are on a par, show close agreement, and are what reasonably might be expected. But, the contributions of the respective factors of cotton quality to converted yarn strength, as evaluated by the beta coefficients, are not in line with the beta values representing actual yarn strength of the yarn size to which conversion was made. Rather, the beta values with converted yarn strength are practically identical in all cases to those previously obtained with actual strength of the yarn size from which conversion was made. No tendencies of any shifts or reversals in the respective contributions of upper half mean length and fiber strength to yarn strength were noted as a result of the conversion process.

Supplementing the over-all correlation analyses referred to above, 12 corresponding analyses were made with actual strength of 14s and 22s yarn and with converted yarn strength for each yarn size converted from the other, by variety, as follows:

24 lots of the Acala 1517 type of cotton, 1948
24 lots of the Acala P-18-C cotton, 1948
36 lots of Coker 100 Wilt cotton, 1948

The data for those lots of cotton were selected out for this special study because of the difference values between strength of 14s yarn converted from strength of 22s yarn and actual strength of 14s yarn, as shown for them in table 10. The values were as follows: Acala 1517, + 5.0 pounds; Acala P-18-C, + 1.7 pounds; and Coker 100 Wilt, - 2.4 pounds. Those cottons also were chosen for this phase of the study because of the K values of yarn strength reported for them in table 11. Their respective K values of yarn strength for the yarn sizes 14s to 22s were, as follows: Acala 1517, 13.0; Acala P-18-C, 18.6; and Coker 100 Wilt, 25.9.

The results obtained from the correlation analyses, by variety, were in general line with those previously mentioned in connection with the entire series of 1948 cottons, and nothing of significance was revealed toward the special problem and objectives under consideration. Limitations in number of observations for the respective varieties, moreover, depreciated the value of results from those analyses. Such being the case, those correlation results are not presented in tabular for in this report.

Evidently, therefore, the reversals reported earlier in this paper for the respective trends of upper half mean length and fiber strength to strength of 14s to 22s yarn, as compared with 22s to 50s yarn, were not merely due to a general or average difference in level of 14s and 22s yarn strength but apparently to the effects of some factor or factors operating in the drafting process of the 14s yarn which were not common to the 22s yarn. Some possible factors and effects along this line will be considered further in the next section of this report. The problem becomes infinitely more complex, however, by virtue of the fact that samples representing different varieties and even different dates of harvesting for a particular variety showed variations in degree and direction of disparities with respect to level of the 14s yarn strength here considered, as compared with corresponding levels of 22s yarn strength. (See tables 10 and 11.)

K Values of Yarn Strength Used as Dependent Variables

A comparison of the $\bar{R}$, $\bar{R}^2$ x 100, absolute $\bar{S}$, relative $\bar{S}$, and beta values obtained from multiple correlation analyses, when using as dependent variables the 6 respective K values of yarn strength representing 6 different ranges of yarn size is shown in table 14. Those results are identified with 277 cottons from the crop year 1948.

<u>14s to 22s yarn</u>. With the K values of yarn strength representing the yarn-size range 14s to 22s, the 6 cotton-quality factors showed a relatively low degree of correlation, as revealed by the $\bar{R}$ value of 0.391. In spite of the low correlation, it is of special interest to note that one fiber property made a statistically significant contribution to the variance in magnitude of the K values for this range of yarn sizes, namely, fiber strength. All other cotton-quality factors failed to produce a statistically significant effect. The beta value for fiber strength, moreover, carried a negative sign which signifies that the higher the fiber strength the smaller was the K value for 14s to 22s yarn. This finding is in line with the observation made earlier in this report to the effect that the relatively low strength of 14s yarn for the Acala 1517 cottons, as compared with their strength of 22s yarn, was--in some complex manner during the drafting process--caused by or associated with the high level of fiber strength generally characteristic of that variety.

This correlation value also confirms the earlier observation to the effect that the comparatively high strength of 14s yarn obtained for the Coker 100 Wilt cottons by the processing organization employed, as compared with their strength of 22s yarn, was caused by or associated with the low level of fiber strength possessed by this variety.

22s to 36s yarn. With the K values of yarn strength for the yarn-size range of 22s to 36s, the coefficient of correlation ($\bar{R}$) was larger than that for 14s to 22s yarn and 3 fiber properties showed a statistically significant contribution to the K values for 22s to 36s yarn, instead of only one for the 14s to 22s yarn. The coefficient of correlation ($\bar{R}$) was 0.693 for the K values representing 22s to 36s yarn and the 3 most important fiber properties to that dependent variable, listed in order of descending importance, were upper half mean length, fiber strength, and fiber fineness (weight per inch). According to the signs attached to the beta values, the longer the upper half mean length the smaller was the K value; the greater the fiber strength the larger was the K value; and the larger the fiber weight per inch the larger was the K value which, when expressed in the more conventional manner, signifies that the finer the fiber the smaller was the K value.

A point of particular interest, in this connection, is the fact that the beta value for fiber strength with the K value representing 22s to 36s yarn was plus, whereas it was minus for 14s to 22s yarn. The signs of the beta value indicate that fiber strength made a contribution in the negative direction to the K values for 14s to 22s yarn and a positive contribution to the K values for 22s to 36s yarn. This is a definite reversal in direction of contribution of fiber strength to the K values, representing the 2 yarn-size ranges, as both beta values were statistically significant; that is, each was more than 3 times its standard error. Those findings further indicate that some one or more influencing or limiting factors were operating in the drafting of the 14s yarn which were absent, or present to a far less degree, in the case of the 22s yarn. Processing details for each of the 2 sizes of yarn under consideration and certain differences known to exist between them will be discussed in the next section.

36s to finest yarn. With the K values of yarn strength representing the yarn-size range 36s to the finest yarn processed from each cotton, the 6 elements of cotton quality showed the lowest degree of correlation of the entire series of K values. The coefficient of multiple correlation ($\bar{R}$) in this instance was only 0.149. All factors of cotton quality failed to make a statistically significant contribution to the K values for 36s to the finest yarn processed. The absence of any appreciable degree of correlation between the cotton-quality elements and K factors for this yarn-size range, however, is understandable because of the highly variable nature in the trend lines for count-strength-product, particularly with the relatively short and coarsed fibered cottons.

14s to 36s yarn. With K values of yarn strength for the yarn-size range 14s to 36s, the 6 factors of cotton-quality gave a coefficient of multiple correlation ($\overline{R}$) of 0.626 which was almost as large as the 0.693 previously reported for the yarn-size range 22s to 36s. Over the range 14s to 36s, 2 fiber properties made a statistically significant contribution to the K values and, listed in order of descending importance, they were upper half mean length and fiber fineness. The longer the upper half mean length the smaller was the K factor, and the finer the fiber the smaller was the K factor.

It is of special interest to note that fiber strength made a statistically insignificant contribution to the K values representing the yarn-size range 14s to 36s. With the K values for 14s to 22s yarn, however, the factor of fiber strength made a statistically significant contribution in the negative direction. With the K values for 22s to 36s yarn, fiber strength caused a statistically significant contribution in the positive direction. Thus, in the case of the yarn-size range 14s to 36s, there was a balancing out of the statistically significant negative and positive contributions of fiber strength to the K values for the respective yarn-size ranges of 14s to 22s and 22s to 36s.

14s to finest yarn. With the K values of yarn strength representing the yarn-size range of 14s to the finest yarn size processed, the 6 factors of cotton quality showed the highest degree of correlation of the entire series of K values. The coefficient of multiple correlation ($\overline{R}$) in this instance was 0.792 and the 2 factors showing a statistically significant contribution were, listed in order of descending importance, fiber fineness and upper half mean length. The finer the fiber the smaller was the K value and the longer the upper half mean length the smaller was the K value.

Fiber strength showed a statistically insignificant contribution to the K values for 14s to the finest yarn spun, as it did toward the K values for 14s to 36s yarn. Thus, a balancing out process occurred in the effect of fiber strength to the K values in this instance because of the statistically significant contribution which it made in the negative direction to the K value of 14s to 22s yarn and the statistically significant contribution which it made in the positive direction to the K values of 22s to 36s yarn. Fiber strength, moreover, failed to make a statistically significant contribution to the K values representing 36s to the finest yarn spun, the latter of which comprised the third yarn-size segment in the range of 14s to the finest yarn processed. Thus, the lack of a statistically significant effect of fiber strength on the K values for 14s to the finest yarn spun from each cotton is understandable.

Average of 3 yarn-size ranges. In the last analysis of this series, averages of the 3 K values representing yarn sizes 14 to 22s, 22s to 36s, and 36s to the finest yarn processed from each cotton were used as the dependent variable. The results obtained are those which reasonably might be expected from a consideration of the findings previously reported for the 3 individual yarn-size-range segments involved. The coefficient of multiple correlation ($\overline{R}$) was 0.523 in this instance, and 3 fiber properties made a statistically significant contribution to the K values in this case. Listed in order of descending importance, they were fiber fineness, upper half mean length, and fiber strength. The finer the fiber the smaller was the K value; the longer the upper half mean length the smaller was the K value; and the greater the fiber strength the smaller was the K value.

The negative sign attached to the statistically significant beta value for the contribution of fiber strength to the average K values representing the 3 yarn-size ranges is in line with its negative statistically significant beta value for 14s to 22s yarn but opposite to that for 22s to 36s yarn. A balancing out process apparently was operating on the relation of fiber strength to the average K values for the 3 yarn-size ranges combined. If so, the negative contribution of fiber strength to the K values for the 14s to 22s yarn was sufficiently greater than the sum of its positive contributions for the 2 other yarn-size segments as to cause a net negative over-all contribution.

Estimated Yarn Strength Used as Dependent Variables

Four multiple correlation analyses were made on the 1948 block of data, using as dependent variables estimated strength of 14s, 22s, 36s, and 50s yarn, as obtained by the 1945-47 count-strength-product equation referred to in publications (13) and (24) on the basis of 6 cotton-quality factors and yarn size. While it was recognized that these analyses represented a so-called forced method of approach and that only different levels of yarn strength identified with the same regression equation were involved, it was thought that the results obtained might offer some points of interest to the complex problem under consideration beyond those given by the other correlation analyses previously considered.

Results from this set of 4 multiple correlation analyses are sented in table 15. It will be noted that perfect correlation was obtained in all cases, the coefficients of correlation ($\bar{R}$) ranging from 0.997 with estimated strength of 50s yarn to 1.000 with estimated strength of 14s yarn. Those values reasonably might be expected in view of the common basis or estimating equation used for obtaining the values which served as the respective dependent variables.

The beta values obtained for the respective factors in each analysis were identical, except for minor variations resulting from rounding off figures in the various calculations. Those findings also are what logically might be expected.

The order of descending importance of the factors to estimated strength of each 14s, 22s, 36s, and 50s yarn was as follows: Fiber strength, fiber fineness, upper half mean length, length uniformity ratio, percentage of mature fibers, and grade index. All beta values in these cases were statistically significant.

No results of significance to the special problem and objectives of this study were obtained from the correlation analyses when the estimated strengths of 4 sizes of yarn were used as respective dependent variables. The beta values so obtained, however, indicate that nothing of significance can be revealed as to the contribution of cotton-quality factors to the strength of different yarn sizes, on the basis of actual or estimated count-strength products representing a collective series of various yarn sizes. That is, the relative contribution of the elements of cotton quality or any factor to strength of yarn of any size can be evaluated only by parallel analyses of actual data segregated by individual yarn size.

POSSIBLE EFFECTS OF SOME FACTORS IN TEXTILE PROCESSING ON EVALUATED CONTRIBUTIONS OF COTTON FIBER PROPERTIES TO YARN STRENGTH

In order for values to provide an adequate basis for revealing the relative contributions of cotton fiber properties to strength of various yarn sizes, it is essential that all yarns of all sizes processed from each and every cotton represent comparable textile processing, as well as construction and twist. Among the many factors involved in the processing of yarns for such purposes, comparable combinations of roving size and drafting factors, limitations in design and efficiency of drafting machines especially for processing coarse yarns, and comparable rates of card production are important matters.

The very noticeable inconsistencies in relative level of strength of 14s yarn shown by the 1948 series of cottons, when stratified by variety and date of harvesting, raise a question as to the cause or causes for those fluctuations. The conspicuous reversals in trends of importance of fiber strength and upper half mean length to yarn strength over the range of 14s to 22s, as compared with their respective and logical trends over the range of 22s to 50s yarn, crop years 1948 and 1949, also raise a question as to the cause or causes for those inconsistencies.

All things considered, the fluctuations and inconsistencies referred to would seem to be more apparent than real because of some variables which were operating during the textile processing of the 14s yarn and not with the 22s, 36s, and 50s yarn, and which were unavoidable with the textile equipment available for these tests. For the same reasons, moreover, it is possible that the gradient shown in the consistent trend for increasing importance of fiber fineness (weight per inch) to yarn strength with decrease in yarn size over the range 14s to 50s may, in reality, be greater than that here reported; that is, if the value obtained for the importance of fiber fineness to the strength of the 14s yarn was influenced or modified to any degree by the same factors of processing that apparently affected the corresponding values obtained for the importance of upper half mean length and fiber strength toward the strength of the 14s yarn.

In the light of the foregoing, therefore, several factors involved in the textile processing of the various yarns are worthy of consideration at this point.

Processing draft in relation to machine design. The textile organization used in processing the 4 sizes of yarn included in this study is indicated by the tabulation shown below:

Yarn Size	Roving Back draft	Roving Front draft	Roving Total draft	Hank roving	Spinning draft
14s	2.94	4.42	13.02	2.50	11.20
22s	3.51	4.82	16.93	3.25	13.54
36s	3.51	4.82	16.93	3.25	22.15
50s	3.51	6.68	23.44	4.50	22.22

It will be noted from the foregoing values that the back draft of the roving frame was constant for the 22s, 36s, and 50s yarn but that it was different and lower for the 14s yarn. The latter, however, was unavoidable because of limitations in the processing machine available, as will be explained later. Also, it will be noted from the previous tabulation that the 14s yarn was processed by a roving total draft considerably lower than that used for making the 22s, 36s and 50s yarn and by a spinning draft very much lower than that used with the 36s and 50s yarn. Finally, it will be noted that the 14s yarn was processed by a spinning draft below that for the 22s and that the spinning draft for the 22s yarn was below that for the 36s and 50s yarn. The comparability of the 22s yarn in this case, however, is not so much in question as the 14s yarn because of the fact that the roving draft of the 22s yarn was higher than that used with the 14s yarn, and also because of the fact that the 22s yarn was spun from a finer hank roving than was the 14s yarn.

The inconsistent findings under consideration for the 14s yarn cannot be explained adequately or entirely on the basis of the drafting factor, alone. That is, a part of those inconsistencies, no doubt, were caused by the design or limitations in design of the superdraft roving frame used in making the coarsest yarn (14s) processed from the cottons included in this study. While the super-draft roving machine is designed for processing drafts from 10 to 72, the fiber control is not sufficiently adequate at or near either drafting extreme to meet the special requirements of such testing and research purposes, as were involved in this instance. The so-called interdraft roving machine, on the other hand, is designed for processing drafts from 6 to 20.

Another factor which enters into this problem and which probably contributed to the inconsistent findings reported herein for the 14s yarn was the fact that the super-draft roving frame used in this instance accommodated four ends (four rovings) under each roll. If that roving frame, for example, had possessed a slightly wider gauge and had involved the use of only two ends (two rovings) under each roll, better control of the fibers probably would have been accomplished than evidently was done with the cottons included in this study, and more comparable results probably would have been obtained for the 14s yarn than were observed in these cases.

In the light of the foregoing, it is obvious that the processing drafts employed in the making of the 14s yarn in these instances were near the lower limit of drafts obtainable on the machines used and that they apparently did not provide adequate control of the fibers to produce results comparable with those obtained with the higher drafts, as in the case of the other yarn sizes involved, namely, 22s, 36s, and 50s. It should be emphasized, however, that it is not the amount of total draft employed as such but, rather, the proportionality of individual drafts and combined drafts in relation to what the machines were designed to produce. All things considered, therefore, it is believed that more comparable and representative results would have been obtained for the 4 respective yarn sizes spun from each cotton, if the 14s yarn had been processed from sliver and roving more comparable in size, more comparable in total draft, and more comparable in proportionality of drafts to those used for processing the 22s, 36s, and 50s yarn.

Rate of card production. As pointed out in an earlier section of this report and as shown in figures 2, 3, and 4, the trends and reversals in magnitude of effects of upper half mean length, fiber strength, and fiber fineness on yarn strength over the range of 14s to 50s yarn were less pronounced and conspicuous in the case of the 1950 cottons than with the 2 series of 1948 and 1949 cottons. Also, it was evident from the data and graphs previously presented that length uniformity ratio, grade index, and percentage of mature fibers made detectable contributions to yarn strength and showed slightly discernible trends in effect on strength of yarn of various sizes in the case of the 1950 cottons, whereas such was not the case with the two series of 1948 and 1949 cottons. The foregoing observations, therefore, prompt a question as to the cause or causes for those disparities.

In the case of the 1948 and 1949 cottons, all were carded at one and the same rate of card production, namely, 9-1/2 pounds per hour. But, with the 1950 cottons, each was processed at one of 3 rates of card production, depending upon the respective staple lengths of the individual cottons. The breakdown of the carding rates used in processing the 305 samples from the 1950 crop was, as follows:

Carding rate	Staple length	Cottons	
Lb. per hr.	Inches	Number	Percent
12.5	15/16 and shorter	45	15
9.5	31/32 to 1-1/16	204	67
6.5	1-3/32 through 1-1/4	56	18

Thus, 45 or 15 percent of the cottons were carded at 12.5 pound per hour; 204 or 67 percent of them were carded at 9.5 pound per hour; and 56 or 18 percent of them were carded at 6-1/2 pound per hour. A total of 101 or 33 percent of the cottons from the 1950 crop, therefore, were carded at either a faster or slower rate of card production that that by which all the 1948 and 1949 cottons were processed, namely, 9-1/2 pound per hour.

While rate of card production from 2.0 to 15.5 pound per hour was found to make only a relatively small contribution to the count-strength product of all yarn sizes collectively, as reported in publication (29) for 10 American upland cottons selected to represent 10 leading varieties grown in commercial production, all cottons were processed at each of the 6 rates of card production and the number of observations was too few to permit analyses with strength of yarn identified with the individual yarn sizes. Thus, that study embraced carding conditions separate and apart from those involved with the 1950 cottons now under consideration and afforded no opportunity for determining, or even observing, any effects of different rates of card production, as identified with various staple-length categories of individual cottons, on the evaluated contributions to yarn strength of the respective cotton quality factors.

The conditions with respect to rate of card production for the 1948 and 1949 cottons used in the present study, however, were very different from those included in the study on rate of card production, as referred to above, and they also were different from the carding conditions employed with the 1950 series of cottons included in the present study. All things considered, therefore, it would appear that the difference in trend of results for the 1950 cottons, as contrasted with those for the 1948 and 1949 cottons, was probably caused to some degree by the 3 carding rates employed with the 1950 samples. The data available in this instance, however, are not adequate for isolating and precisely determining the effect of the factor of carding rate on the evaluated contributions of the cotton-quality factors to yarn strength.

Use of converted strength of 14s yarn. In the case of the 1948 and 1949 cottons, all samples were spun into 14s yarn and their actual strength data were used in the respective analyses. For the 1950 samples, however, 56 of the longest cottons out of the total 305, or 18 percent of them, were not spun into 14s yarn. In those cases, 22s yarn was the coarsest size processed. Thus, the strength values used in the analysis for those 56 lots of 14s yarn were converted from actual strength representing their corresponding 22s yarn.

As pointed out earlier in this report and as shown by the beta values listed in table 13, the evaluated contributions of the respective cotton-quality factors to yarn strength represented those for the yarn size from which conversions were made and not those of the yarn size to which they were adjusted. The beta values identified with the strength of 14s yarn for the 1950 cottons, therefore, represented--in effect--a combination of the respective beta values for 14s and 22s yarn. It is felt that such a status with the 1950 cottons offset in some degree the differential in drafting effects noted with the 14s yarn in the case of the 1948 and 1949 cottons. If so, that condition probably reduced or eliminated the showing of any pronounced reversals in trend of contribution of upper half mean length and fiber strength to strength of 14s to 22s yarn for the 1950 cottons, as compared with that for their 22s to 36s yarn; and it may have prevented the showing of any substantial increase in importance of fiber fineness (weight per inch) to strength of yarn from 14s to 36s.

DISCUSSION

Some consideration has been given in the previous sections of this report to certain drafting factors which operate in the textile organization used for processing raw cotton into yarns, and which apparently influence more or less the level of yarn strength realized, the evaluated relations obtained between certain fiber properties and yarn strength, and the evaluated contributions obtained for some fiber properties to yarn strength. In connection with the findings presented in this report, therefore, it is of interest to examine three sets of experimental results that recently were obtained at the Department's Southern Regional Research Laboratory, New Orleans, La., on the subject of drafts and drafting processes used in the cotton textile industry. A brief account of those studies and findings now follows.

Corley (4) studied the drafting of relatively long, fine-fibered cottons on a long-draft roving system with a compound drafting section or dual drafting zone which permitted mechanical drafts from 10 to 72. Corley experienced some difficulties in processing comparatively long, fine-fibered cottons when using the generally recommended draft-change-gear specifications. He also observed that long, fine-fibered cottons were significantly more sensitive to the process of drafting than short, coarse-fibered cottons; and that long, fine-fibered cottons required different and more precise distributions of zone drafts, as compared with those required for short, coarse-fibered cottons.

Corley and Simpson (5) studied the draft proportionment for coarse, short-staple cotton on three different long-draft roving systems. Their results, as well as those of Corley (4), revealed that the level of roving uniformity generally obtained with long-draft systems can be significantly improved through better proportionment of zone drafts. Although the new draft guides proposed by those investigators enabled the production of more uniform rovings and yarns from the selected cottons used, with corresponding improvement in yarn strength, it should be emphasized that the improved draft proportionments suggested by those investigators may not prove to be optimum for all prevailing types of cotton and conditions encountered in the cotton trade and textile industry.

Fiori (6) studied the effect of draft distribution in drawing, roving, and spinning processes on the skein strength and appearance of a low twist, coarse cotton yarn (15.75s). He conducted a series of identical processing experiments on yarns representing 4 different types of cotton and a wide range of staple lengths. An all-purpose long-draft roving frame capable of making the required range of hank rovings (1.25 to 2.50) was used by Fiori in his study, and the spinning was done on a long-draft system.

The most striking effect of the draft changes used in Fiori's tests was observed during the spinning process. Increases in draft at the spinning frame, from 12.6 to 25.2, caused an appreciable reduction in the skein strength of the resulting yarns. The coefficients of variation for the skein strength of yarns, representing the four spinning groups of cotton, indicated that increasing the draft also increased the dispersion interval to the extent that objectionably large variations in results from the yarn skein-strength tests were obtained, as the highest draft (25.2) was approached.

In summarizing the published results from Fiori's study (6), it is evident that, while they confirm the primary purpose of long-draft spinning and the introduction of "controlled" drafting during spinning, they demonstrate the futility of indiscriminate drafting in this process. Fiori's findings, however, were identified with only one size of yarn; with only a comparatively coarse yarn (15.75s); and with relatively low twist multipliers used in spinning the yarns--those appropriate to the manufacture of tire cord. Such low twist multipliers, of course, automatically give comparatively low yarn strength. How far, therefore, Fiori's reported findings for such a coarse, low-twist type of yarn will apply to all sizes of yarn and twist multipliers, over a wide range, is problematical. There is reason to believe, moreover, that the effects of drafting will be found to be somewhat less severe and critical with finer sizes of yarn processed with larger twist multipliers than those reported by Fiori for his very coarse, low-twist type of yarn.

A paper recently published in England by Cavaney and Foster (3) deals with some measurements of the force required to draft cotton and rayon-staple slivers and, therefore, is of background interest to the problems under discussion herein. The effects of draft, compactness of the sliver, direction and speed of drafting, and fiber properties upon the drafting force are discussed in the publication cited, and a few experiments on the correlation between drafting force and drafting irregularity are described.

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APPENDIX

Table 1.--Comparison of statistical values, representing data identified with various independent and dependent variables used in multiple correlation analyses, for cottons from selected cotton improvement groups, by crop year, 1948-50

Crop year	Factors used in analysis, as--	Value for-- Observations 1/	Mean	Standard deviation	Maximum	Minimum	Range
		Number					
1948	Independent variables:						
	Grade of cotton .... index	277	98.14	± 5.56	105.	76.	29.
	Upper half mean length .... inch	277	1.04	± .08	1.25	.83	.42
	Length uniformity ratio .... index	277	78.56	± 2.38	93.	72.	21.
	Fiber fineness (wt. per in.) ... microgram	277	4.23	± .49	5.7	3.1	2.6
	Fiber strength ..... 1,000 lb. per sq. in.	277	80.90	± 6.34	98.	70.	28.
	Mature fibers (standard method) .. percent	277	79.00	± 4.54	88.	64.	24.
	Yarn size .... number	1,108	32.23	± 16.53	60.	14.	46.
	Dependent variables:						
	Strength of 14s yarn .... pound	277	188.34	± 15.23	237.	155.	82.
	Strength of 22s yarn .... pound	277	111.77	± 10.16	147.	88.	59.
	Strength of 36s yarn .... pound	277	60.40	± 7.10	81.	43.	38.
	Strength of 50s yarn .... pound	277	40.64	± 5.68	57.	26.	31.
	Count-strength product .... csp	1,108	2,287.39	±365.01	3,318.	1,408.	1,910.
1949	Independent variables:						
	Grade of cotton .... index	260	97.27	± 4.42	105.	75.	30.
	Upper half mean length .... inch	260	1.07	± .06	1.28	.86	.42
	Length uniformity ratio .... index	260	78.66	± 2.26	84.	70.	14.
	Fiber fineness (wt. per in.) ... microgram	260	4.34	± .50	5.8	2.9	2.9
	Fiber strength 1,000 lb. per sq. in.	260	78.15	± 5.29	95.	65.	30.
	Mature fibers (standard method) .. percent	260	84.85	± 3.95	94.	69.	25.
	Yarn size .... number	1,040	30.50	± 13.74	50.	14.	36.
	Dependent variables:						
	Strength of 14s yarn .... pound	260	190.48	± 20.44	252.	126.	126.
	Strength of 22s yarn .... pound	260	113.30	± 12.55	153.	75.	78.
	Strength of 36s yarn .... pound	260	61.63	± 7.08	83.	40.	43.
	Strength of 50s yarn .... pound	260	39.23	± 5.29	56.	25.	31.
	Count-strength product .... csp	1,040	2,334.86	±381.14	3,598.	1,250.	2,348.
1950	Independent variables:						
	Grade of cotton .... index	305	97.42	± 5.06	104.	75.	29.
	Upper half mean length .... inch	305	1.06	± .07	1.25	.85	.40
	Length uniformity ratio .... index	305	78.63	± 2.03	85.	72.	13.
	Fiber fineness (wt. per in.) ... microgram	305	4.31	± .56	5.9	2.5	3.4
	Fiber strength ..... 1,000 lb. per sq. in.	305	76.23	± 6.07	91.	60.	31.
	Mature fibers (standard method) .. percent	305	79.96	± 6.36	92.	50.	42.
	Yarn size .... number	1,119	30.54	± 13.30	50.	14.	36.
	Dependent variables:						
	Strength of 14s yarn .... pound	305	177.03	± 24.17	258.	126.	132.
	Strength of 22s yarn .... pound	305	106.09	± 14.93	156.	74.	82.
	Strength of 36s yarn .... pound	305	58.10	± 9.04	89.	37.	52.
	Strength of 50s yarn .... pound	305	36.59	± 6.76	59.	21.	38.
	Count-strength product .... csp	1,119	2,177.69	±354.00	3,432.	1,200.	2,232.

1/ Values shown indicate the number of observations used in each correlation analysis.

Table 2.--Comparison of statistical values obtained from multiple correlation analysis for six elements of raw-cotton quality with strength of each 14s, 22s, 36s, and 50s yarn, and with count-strength product of all yarn sizes spun, representing cottons from selected cotton improvement groups, by crop year, 1948-50

Dependent variable	Lots of-- Cotton	Lots of-- Yarn	Observations 1/	Independent variables 2/	Statistical value $\bar{R}$	$\bar{R}^2$ x 100	$\bar{S}$ Absolute 3/	$\bar{S}$ Relative 4/
	Number	Number	Number	Number		Percent		Percent
Crop year of 1948:								
Strength of 14s yarn	277	277	277	6	0.871 ± 0.014	75.9	± 7.48	± 3.97
Strength of 22s yarn	277	277	277	6	.878 ± .014	77.1	± 4.87	± 4.36
Strength of 36s yarn	277	277	277	6	.880 ± .014	77.5	± 3.38	± 5.60
Strength of 50s yarn	277	277	277	6	.906 ± .011	82.1	± 2.41	± 5.93
Count-strength product of all yarn sizes	277	1,108	1,108	5/ 7	.945 ± .003	89.3	±119.54	± 5.23
Crop year of 1949:								
Strength of 14s yarn	260	260	260	6	.852 ± .017	72.6	± 10.73	± 5.63
Strength of 22s yarn	260	260	260	6	.881 ± .014	77.5	± 5.96	± 5.26
Strength of 36s yarn	260	260	260	6	.884 ± .014	78.1	± 3.32	± 5.39
Strength of 50s yarn	260	260	260	6	.890 ± .013	79.2	± 2.42	± 6.17
Count-strength product of all yarn sizes	260	1,040	1,040	5/ 7	.942 ± .003	88.7	±127.01	± 5.48
Crop year of 1950:								
Strength of 14s yarn	305	305	305	6	.870 ± .014	75.6	± 11.94	± 6.74
Strength of 22s yarn	305	305	305	6	.880 ± .013	77.4	± 7.11	± 6.70
Strength of 36s yarn	305	305	305	6	.892 ± .012	79.6	± 4.09	± 7.04
Strength of 50s yarn	305	305	305	6	.889 ± .012	79.1	± 3.10	± 8.47
Count-strength product of of all yarn sizes	305	1,119	1,119	5/ 7	.904 ± .005	81.8	±151.00	± 6.93

1/ Values shown indicate the number of observations used in each correlation analysis.

2/ Six elements of raw-cotton quality were included in all analyses, as follows: Grade index, upper half mean length, length uniformity ratio, fiber fineness (weight per inch), fiber strength, and percentage of mature fibers (standard method).

3/ For strength of the individual sizes of yarn, the standard error of estimate ($\bar{S}$) is expressed in terms of pounds; for count-strength product, it is in csp units.

4/ Absolute value of standard error of estimate ($\bar{S}$) divided by the respective mean value for the dependent variable, multiplied by 100.

5/ When count-strength product of all yarn sizes was used as the dependent variable, yarn size was included in the analysis as an additional independent variable.

Table 3.--Comparison of relative importance of six elements of raw-cotton quality to strength of each 14s, 22s, 36s, and 50s carded yarn and to count-strength product of all yarn sizes, as evaluated by multiple correlation analysis, representing cottons from selected cotton improvement groups, crop year 1948

Factors of cotton quality	Observations	Rank	Beta coefficient 1/
	Number		
Strength of 14s yarn with:	277		
Upper half mean length		1	+0.725 ± 0.036
Fiber strength		2	+ .381 ± .032
Fiber weight per inch		3	- .235 ± .047
Grade index		4	+ .167 ± .032
Length uniformity ratio		5	+ .140 ± .032
Percentage of mature fibers		6	- .009* ± .043
Strength of 22s yarn with:	277		
Upper half mean length		1	+ .693 ± .035
Fiber strength		2	+ .470 ± .031
Fiber weight per inch		3	- .280 ± .046
Grade index		4	+ .158 ± .031
Length uniformity ratio		5	+ .105 ± .032
Percentage of mature fibers		6	- .019* ± .042
Strength of 36s yarn with:	277		
Upper half mean length		1	+ .732 ± .035
Fiber strength		2	+ .341 ± .031
Fiber weight per inch		3	- .304 ± .045
Length uniformity ratio		4	+ .119 ± .031
Grade index		5	+ .113 ± .031
Percentage of mature fibers		6	.000 ± .041
Strength of 50s yarn with:	277		
Upper half mean length		1	+ .744 ± .031
Fiber weight per inch		2	- .354 ± .040
Fiber strength		3	+ .264 ± .028
Length uniformity ratio		4	+ .140 ± .028
Grade index		5	+ .095 ± .027
Percentage of mature fibers		6	+ .041* ± .037
Count-strength product with:	1,108		
Yarn size		1	- .783 ± .010
Upper half mean length		2	+ .472 ± .012
Fiber strength		3	+ .239 ± .011
Fiber weight per inch		4	- .196 ± .016
Grade index		5	+ .089 ± .011
Length uniformity ratio		6	+ .083 ± .011
Percentage of mature fibers		7	+ .002* ± .014

1/ The sign indicates the direction of the contribution of the independent variable to the dependent variable.

* Statistically insignificant, being less than 3 times its standard error.

Table 4.--Comparison of relative importance of six elements of raw-cotton quality to strength of each 14s; 22s, 36s, and 50s carded yarn and to count-strength product of all yarn sizes, as evaluated by multiple correlation analysis, representing cottons from selected cotton improvement groups, crop year 1949

Factors of cotton quality	Observations	Rank	Beta coefficient 1/
	Number		
Strength of 14s yarn with:	260		
Upper half mean length		1	+0.423 ± 0.040
Fiber strength		2	+ .404 ± .038
Grade index		3	+ .206 ± .039
Fiber weight per inch		4	- .148* ± .050
Length uniformity ratio		5	+ .094* ± .040
Percentage of mature fibers		6	+ .057* ± .041
Strength of 22s yarn with:	260		
Fiber strength		1	+ .451 ± .034
Upper half mean length		2	+ .395 ± .036
Grade index		3	+ .198 ± .035
Fiber weight per inch		4	- .195 ± .045
Length uniformity ratio		5	+ .064* ± .036
Percentage of mature fibers		6	+ .022* ± .037
Strength of 36s yarn with:	260		
Fiber strength		1	+ .405 ± .034
Upper half mean length		2	+ .400 ± .036
Fiber weight per inch		3	- .241 ± .045
Grade index		4	+ .213 ± .035
Length uniformity ratio		5	+ .061* ± .035
Percentage of mature fibers		6	.000 ± .037
Strength of 50s yarn with:	260		
Upper half mean length		1	+ .469 ± .035
Fiber strength		2	+ .360 ± .033
Fiber weight per inch		3	- .276 ± .044
Grade index		4	+ .166 ± .034
Length uniformity ratio		5	+ .066* ± .035
Percentage of mature fibers		6	+ .037* ± .036
Count-strength product with:	1,040		
Yarn size		1	- .704 ± .010
Upper half mean length		2	+ .428 ± .013
Fiber strength		3	+ .320 ± .012
Fiber weight per inch		4	+ .200 ± .016
Percentage of mature fibers		5	- .136 ± .013
Grade index		6	+ .106 ± .013
Length uniformity ratio		7	- .069 ± .013

1/ The sign indicates the direction of the contribution of the independent variable to the dependent variable.

* Statistically insignificant, being less than 3 times its standard error.

Table 5.--Comparison of relative importance of six elements of raw-cotton quality to strength of each 14s, 22s, 36s and 50s carded yarn and to count-strength product of all yarn sizes, as evaluated by multiple correlation analysis, representing cottons from selected cotton improvement groups, crop year 1950

Factors of cotton quality	Observations	Rank	Beta coefficient 1/
	Number		
Strength of 14s yarn with:	305		
Fiber strength		1	+0.452 ± 0.032
Fiber weight per inch		2	- .374 ± .044
Upper half mean length		3	+ .342 ± .033
Length uniformity ratio		4	+ .234 ± .031
Percentage of mature fibers		5	+ .138 ± .045
Grade index		6	+ .128 ± .033
Strength of 22s yarn with:	305		
Fiber strength		1	+ .458 ± .031
Fiber weight per inch		2	- .374 ± .043
Upper half mean length		3	+ .358 ± .032
Length uniformity ratio		4	+ .224 ± .030
Grade index		5	+ .131 ± .032
Percentage of mature fibers		6	+ .122* ± .044
Strength of 36s yarn with:	305		
Fiber strength		1	+ .441 ± .030
Upper half mean length		2	+ .417 ± .030
Fiber weight per inch		3	- .369 ± .040
Length uniformity ratio		4	+ .131 ± .028
Percentage of mature fibers		5	+ .141 ± .041
Grade index		6	+ .119 ± .030
Strength of 50s yarn with:	305		
Upper half mean length		1	+ .426 ± .030
Fiber weight per inch		2	- .422 ± .041
Fiber strength		3	+ .399 ± .030
Length uniformity ratio		4	+ .194 ± .029
Percentage of mature fibers		5	+ .172 ± .042
Grade index		6	+ .104 ± .031
Count-strength product with:	1,119		
Yarn size		1	- .634 ± .013
Fiber strength		2	+ .389 ± .014
Fiber weight per inch		3	- .326 ± .020
Upper half mean length		4	+ .314 ± .014
Length uniformity ratio		5	+ .200 ± .014
Percentage of mature fibers		6	+ .120 ± .020
Grade index		7	+ .105 ± .015

1/ The sign indicates the direction of the contribution of the independent variable to the dependent variable.

* Statistically insignificant, being less than 3 times its standard error.

Table 6 .--Comparison of ranks of relative importance of six elements of raw cotton quality to strength of each 14s, 22s, 36s, and 50s yarn and to count-strength product of all yarn sizes, as based on beta coefficients obtained from multiple correlation analysis, representing cottons from selected cotton improvement groups, by crop year, 1948-50

Factors of cotton quality	Rank of importance in--			Frequency of ranks--						
	1948	1949	1950	1st.	2d.	3d.	4th.	5th.	6th.	7th.
With strength of 14s yarn:										
Upper half mean length	1	1	3	2	-	1	-	-	-	-
Fiber strength	2	2	1	1	2	-	-	-	-	-
Fiber weight per inch	3	4*	2	-	1	1	1	-	-	-
Grade index	4	3	6	-	-	1	1	-	1	-
Length uniformity ratio	5	5*	4	-	-	-	1	2	-	-
Percentage of mature fibers	6*	6*	5	-	-	-	-	1	2	-
With strength of 22s yarn:										
Upper half mean length	1	2	3	1	1	1	-	-	-	-
Fiber strength	2	1	1	2	1	-	-	-	-	-
Fiber weight per inch	3	4	2	-	1	1	1	-	-	-
Grade index	4	3	5	-	-	1	1	1	-	-
Length uniformity ratio	5	5*	4	-	-	-	1	2	-	-
Percentage of mature fibers	6*	6*	6*	-	-	-	-	-	3	-
With strength of 36s yarn:										
Upper half mean length	1	2	2	1	2	-	-	-	-	-
Fiber strength	2	1	1	2	1	-	-	-	-	-
Fiber weight per inch	3	3	3	-	-	3	-	-	-	-
Length uniformity ratio	4	5*	4	-	-	-	2	1	-	-
Grade index	5	4	6	-	-	-	1	1	1	-
Percentage of mature fibers	6*	6*	5	-	-	-	-	1	2	-
With strength of 50s yarn:										
Upper half mean length	1	1	1	3	-	-	-	-	-	-
Fiber weight per inch	2	3	2	-	2	1	-	-	-	-
Fiber strength	3	2	3	-	1	2	-	-	-	-
Length uniformity ratio	4	5*	4	-	-	-	2	1	-	-
Grade index	5	4	6	-	-	-	1	1	1	-
Percentage of mature fibers	6*	6*	5	-	-	-	-	1	2	-
With count-strength product of all yarn sizes:										
Yarn size	1	1	1	3	-	-	-	-	-	-
Upper half mean length	2	2	4	-	2	-	1	-	-	-
Fiber strength	3	3	2	-	1	2	-	-	-	-
Fiber weight per inch	4	4	3	-	-	1	2	-	-	-
Grade index	5	6	7	-	-	-	-	1	1	1
Length uniformity ratio	6	7	5	-	-	-	-	1	1	1
Percentage of mature fibers	7*	5	6	-	-	-	-	1	1	1

* Value of beta coefficient was statistically insignificant, being less than 3 times its standard error.

Table 7.--Comparison of relative contribution of six factors of raw-cotton quality to skein strength of each 14s, 22s, 36s, and 50s carded yarn and to count-strength product of all yarn sizes spun, as derived from calculations based on values of beta coefficients obtained from multiple correlation analysis, representing cottons from selected cotton improvement groups, by crop year, 1948-50 1/

Crop year	Cottons 2/	Factors of cotton quality	Relative contribution to-- Strength of 14s yarn 3/	Strength of 22s yarn	Strength of 36s yarn	Strength of 50s yarn 4/	Count-strength product of all yarn sizes
	Number		Percent	Percent	Percent	Percent	Percent
1948	277	Upper half mean length	51.56	45.38	53.82	58.35	21.03
		Fiber strength	14.25	20.87	11.68	7.35	5.39
		Fiber fineness (wt. per in.)	5.42	7.41	9.28	13.21	3.62
		Grade index	2.74	2.36	1.29	.95	.75
		Length uniformity ratio	1.92	1.04	1.43	2.06	.65
		Percentage of mature fibers	.01	.04	.00	.18	.00
		Yarn size	--	--	--	--	57.86
		Total variance in dependent variable explained ($\bar{R}^2$ x 100)	75.90	77.10	77.50	82.10	89.30
		Mechanical and other factors not measured	24.10	22.90	22.50	17.90	10.70
		Total	100.00	100.00	100.00	100.00	100.00
1949	260	Upper half mean length	31.04	27.40	28.98	37.95	18.99
		Fiber strength	28.32	35.73	29.71	22.35	10.61
		Grade index	7.35	6.89	8.22	4.76	1.16
		Fiber fineness (wt. per in.)	3.80	6.67	10.52	13.14	4.15
		Length uniformity ratio	1.53	.72	.67	.76	.50
		Percentage of mature fibers	.56	.09	.00	.24	1.92
		Yarn size	--	--	--	--	51.37
		Total variance in dependent variable explained ($\bar{R}^2$ x 100)	72.60	77.50	78.10	79.20	88.70
		Mechanical and other factors not measured	27.40	22.50	21.90	20.80	11.30
		Total	100.00	100.00	100.00	100.00	100.00
1950	305	Fiber strength	28.01	28.99	27.09	21.10	15.03
		Fiber fineness (wt. per in.)	19.18	19.33	18.97	23.61	10.56
		Upper half mean length	16.04	17.71	24.22	24.06	9.79
		Length uniformity ratio	7.51	6.93	4.57	4.98	3.97
		Percentage of mature fibers	2.61	2.06	2.77	3.92	1.43
		Grade index	2.25	2.38	1.98	1.43	1.09
		Yarn size	--	--	--	--	39.93
		Total variance in dependent variable explained ($\bar{R}^2$ x 100)	75.60	77.40	79.60	79.10	81.80
		Mechanical and other factors not measured	24.40	22.60	20.40	20.90	18.20
		Total	100.00	100.00	100.00	100.00	100.00

1/ Each value shown for the contribution of a cotton-quality factor and yarn size to a dependent variable represents the value of its beta coefficient, as obtained from multiple correlation analysis, squared and multiplied by 100, with the total interactions and residuals apportioned to each factor in proportion to the amount of variance explained in the dependent variable by it.

2/ The number of cottons shown for each crop year indicates the number of observations used in the respective correlation analyses for the individual yarn sizes. For count-strength product of all yarn sizes spun, the number of observations used in each analysis was as follows: (1948) 1,108; (1949) 1,040; and (1950) 1,119.

3/ For the crop year of 1950, 56 cottons out of the total 305 were not spun into 14s yarn. In those cases, strength of 14s yarn was estimated from strength of 22s yarn by use of the conversion formula reported in publication (2).

4/ For the crop year of 1948, 210 cottons out of the total 277 were spun into 60s as the finest yarn size processed. In those cases, strength of 50s yarn was converted from the strength of 60s yarn by the formula referred to above. In 31 cases, 44s was the finest yarn size spun. In those instances, strength of 50s yarn was converted from strength of 44s by the formula cited. For the crop year of 1950, 45 cottons out of the total 305 were spun into 36s as the finest yarn size spun which necessitated, in those cases, strength of 50s yarn being obtained from strength of 36s yarn by the conversion formula.

Table 8.--Comparison of average relative contribution of six respective factors of raw-cotton quality to skein strength of each 14s, 22s, 36s and 50s carded yarn, as derived from calculations based on values of beta coefficients obtained from multiple correlation analysis, representing cottons from selected cotton improvement groups, by crop year, 1948-50 1/

Factors of cotton quality	Relative contribution to yarn strength for years of--			
	1948 (277 cottons) 2/	1949 (260 cottons)	1950 (305 cottons) 3/	Average (842 cottons)
	Percent	Percent	Percent	Percent
With strength of 14s yarn:				
Upper half mean length	51.56	31.04	16.04	32.88
Fiber strength	14.25	28.32	28.01	23.53
Fiber fineness (wt. per in.) ...	5.42	3.80	19.18	9.47
Grade index	2.74	7.35	2.25	4.11
Length uniformity ratio	1.92	1.53	7.51	3.65
Percentage of mature fibers	.01	.56	2.61	1.06
With strength of 22s yarn:				
Upper half mean length	45.38	27.40	17.71	30.16
Fiber strength	20.87	35.73	28.99	28.53
Fiber fineness (wt. per in.) ...	7.41	6.67	19.33	11.14
Grade index	2.36	6.89	2.38	3.88
Length uniformity ratio	1.04	.72	6.93	2.90
Percentage of mature fibers	.04	.09	2.06	.73
With strength of 36s yarn:				
Upper half mean length	53.82	28.98	24.22	35.67
Fiber strength	11.68	29.71	27.09	22.83
Fiber fineness (wt. per in.) ...	9.28	10.52	18.97	12.92
Grade index	1.29	8.22	1.98	3.83
Length uniformity ratio	1.43	.67	4.57	2.22
Percentage of mature fibers	.00	.00	2.77	.92
With strength of 50s yarn:				
Upper half mean length	58.35	37.95	24.06	40.12
Fiber strength	7.35	22.35	21.10	16.93
Fiber fineness (wt. per in.) ...	13.21	13.14	23.61	16.65
Grade index	.95	4.76	1.43	2.38
Length uniformity ratio	2.06	.76	4.98	2.60
Percentage of mature fibers	.18	.24	3.92	1.45

1/ Each value shown for the contribution of a cotton-quality factor to a dependent variable represents the value of its beta coefficient, as obtained from multiple correlation analysis, squared and multiplied by 100, with the total interactions and residuals apportioned to each factor in proportion to the amount of variance explained in the dependent variable by it.

2/ For the crop year of 1948, 210 cottons were spun into 60s as the finest yarn processed. In those cases, strength of 50s yarn was converted from the strength of 60s yarn by the conversion formula reported in publication (2). In 31 cases, 44s was the finest yarn size spun. In those instances, strength of 50s yarn was converted from strength of 44s by the formula cited.

3/ For the crop year of 1950, 56 cottons were not spun into 14s yarn. In those cases, strength of 14s yarn was converted from strength of 22s by the same formula. Also, 45 cottons were spun into 36s as the finest yarn processed which necessitated, in those cases, strength of 50s yarn being obtained from strength of 36s yarn by the conversion formula.

Table 9.--Comparison of average values for 6 elements of raw-cotton quality and skein strength of 4 sizes of carded long-draft yarn, representing cottons by variety and date of harvesting, from selected cotton improvement groups, crop year 1948

Variety	Date of harvesting	Lots of cotton 1/	Factors of cotton quality, including--						Strength for yarn sizes of--			
			Grade	Upper half mean length	Uniformity ratio	Fiber weight per inch	Mature fibers	Fiber strength	14s	22s	36s	50s
			Index	Inches	Index	Micrograms	Percent	1,000 lb. per sq. in.	Pounds	Pounds	Pounds	Pounds
Acala 1517 (including 2815 and WR) and Acala 4-42	Early	8	104.0	1.121	79.5	4.22	81.0	92.1	222.5	138.1	75.9	51.9
	Midseason	8	103.0	1.125	79.0	4.11	79.7	91.5	211.4	130.4	70.7	47.6
	Late	8	99.7	1.084	79.5	4.04	78.1	87.6	207.4	125.5	69.9	47.0
	Mean	24	102.2	1.110	79.3	4.12	79.6	90.4	213.7	131.3	72.2	48.8
Acala P-18-C	Early	8	103.5	1.056	79.0	4.09	80.5	75.5	183.2	110.2	59.5	40.2
	Midseason	8	100.5	1.066	78.2	4.14	79.2	75.6	183.6	109.0	57.5	39.7
	Late	8	100.0	1.011	78.1	3.82	75.9	75.9	173.2	104.1	55.1	37.2
	Mean	24	101.3	1.045	78.5	4.02	78.5	75.7	180.0	107.8	57.4	39.1
Stoneville 2B	Early	11	100.4	1.065	78.4	3.84	74.8	83.1	197.9	119.6	66.2	45.4
	Midseason	11	99.1	1.062	77.9	3.93	78.0	83.3	196.2	117.5	65.0	44.5
	Late	10	92.8	1.030	77.8	3.87	77.3	83.6	189.5	112.8	61.5	41.3
	Mean	32	97.6	1.053	78.0	3.88	76.7	83.3	194.7	116.8	64.3	43.8
Rowden	Early	10	103.5	.940	78.3	5.11	81.9	86.9	169.7	100.2	50.4	31.7
	Midseason	10	102.9	.950	78.1	5.07	81.3	87.4	171.8	99.6	50.4	32.2
	Late	10	100.9	.924	78.1	5.17	82.9	86.9	165.6	97.1	47.9	30.0
	Mean	30	102.4	.938	78.2	5.12	82.0	87.1	169.0	99.0	49.6	31.3
Deltapine 14	Early	29	100.7	1.077	78.8	4.29	80.2	79.8	196.3	116.1	63.8	43.4
	Midseason	28	97.8	1.063	78.2	4.21	79.0	78.9	191.6	112.9	61.7	41.9
	Late	26	91.7	1.038	78.3	4.13	79.1	77.3	183.5	108.3	58.7	39.5
	Mean	83	96.9	1.060	78.5	4.21	79.5	78.7	190.7	112.6	61.5	41.7
Coker 100 Wilt	Early	14	98.7	1.109	81.9	4.23	80.5	77.4	197.1	115.2	64.0	44.6
	Midseason	11	93.2	1.083	78.9	4.15	80.8	78.0	185.9	109.0	60.1	41.4
	Late	11	89.9	1.060	77.0	4.15	79.5	76.4	179.6	105.8	58.0	39.3
	Mean	36	94.3	1.086	79.5	4.18	80.3	77.3	188.4	110.4	61.0	42.0
Miscellaneous varieties	Early	17	99.3	.994	73.7	4.24	76.9	80.7	186.9	109.8	59.0	39.0
	Midseason	16	98.2	1.008	78.4	4.11	77.3	79.6	184.5	108.7	58.6	39.1
	Late	15	93.2	.978	77.9	4.07	76.1	79.0	178.7	105.9	56.0	36.7
	Mean	48	97.2	.994	73.4	4.14	76.8	79.8	183.5	108.2	57.9	38.3
All varieties	Early	97	101.0	1.053	79.2	4.28	79.3	81.4	193.3	114.9	62.5	42.3
	Midseason	92	98.7	1.049	78.4	4.23	79.2	81.2	189.1	112.0	60.6	40.9
	Late	88	94.4	1.018	78.1	4.17	78.5	80.1	182.1	108.0	57.9	38.6
	Mean	277	98.1	1.041	78.6	4.23	79.0	80.9	188.3	111.8	60.4	40.6

1/ Each lot of cotton for a particular variety and date of harvesting represents a different location of growth or cotton improvement group.

Table 10.--Comparison of average differences between values of converted strength and actual strength for 2 sizes of carded yarn, representing cottons by variety and date of harvesting, from selected cotton improvement groups, crop year 1948 1/

Variety	Date of harvesting	Lots of cotton 2/	Absolute values for-- 14s yarn converted from 22s	Absolute: 14s yarn converted from 36s	Absolute: 22s yarn converted from 36s	Absolute: 22s yarn converted from 14s	Relative values for-- 14s yarn converted from 22s	Relative: 14s yarn converted from 36s	Relative: 22s yarn converted from 36s	Relative: 22s yarn converted from 14s
		Number	Pounds	Pounds	Pounds	Pounds	Percent 3/	Percent 3/	Percent 4/	Percent 4/
Acala 1517 (including 2815 and WR) and Acala 4-42	Early	8	+6.9	+6.9	-0.2	-4.5	+3.1	+3.1	-0.2	-3.3
	Midseason	8	+5.9	+4.5	- .7	-3.8	+2.8	+2.1	- .6	-2.9
	Late	8	+2.1	+6.5	+2.6	-1.6	+1.0	+3.1	+2.1	-1.3
	Mean	24	+5.0	+6.0	+ .5	-3.3	+2.3	+2.8	+ .4	-2.5
Acala P-18-C	Early	8	+2.1	+3.9	+ .9	-1.6	+1.1	+2.1	+ .8	-1.4
	Midseason	8	+ .1	-1.6	-1.2	.0	+ .1	- .9	-1.1	.0
	Late	8	+2.9	+2.7	- .2	-1.9	+1.7	+1.6	- .2	-1.8
	Mean	24	+1.7	+1.7	- .2	-1.2	+ .9	+ .9	- .2	-1.1
Stonsville 2B	Early	11	+2.5	+6.4	+2.5	-1.5	+1.3	+3.3	+2.1	-1.2
	Midseason	11	+ .8	+5.2	+2.6	- .5	+ .4	+2.6	+2.2	- .4
	Late	10	+ .3	+2.9	+1.6	- .1	+ .2	+1.5	+1.4	- .1
	Mean	32	+1.2	+4.9	+2.3	- .7	+ .6	+2.5	+1.9	- .6
Rowden	Early	10	+ .2	-5.9	-3.9	.0	+ .1	-3.5	-3.9	.0
	Midseason	10	-2.9	-8.1	-3.2	+1.7	-1.7	-4.7	-3.2	+1.7
	Late	10	- .6	-8.2	-5.0	+ .3	- .4	-4.9	-5.1	+ .3
	Mean	30	-1.1	-7.4	-4.0	+ .7	- .7	-4.4	-4.1	+ .7
Deltapine 14	Early	29	-1.6	+2.0	+2.2	+ .9	- .8	+1.0	+1.9	+ .8
	Midseason	28	-1.8	+1.1	+1.9	+1.2	- .9	+ .6	+1.7	+1.1
	Late	26	- .7	+1.5	+1.3	+ .5	- .4	+ .8	+1.2	+ .5
	Mean	83	-1.4	+1.5	+1.8	+ .8	- .7	+ .8	+1.6	+ .8
Coker 100 Wilt	Early	14	-3.7	+1.5	+3.3	+2.3	-1.9	+ .8	+2.8	+2.0
	Midseason	11	-2.4	+2.6	+3.2	+1.3	-1.3	+1.4	+2.9	+1.2
	Late	11	- .7	+3.6	+2.9	+ .6	- .4	+2.0	+2.7	+ .6
	Mean	36	-2.4	+2.5	+3.1	+1.4	-1.3	+1.3	+2.8	+1.3
Miscellaneous varieties	Early	17	-2.1	-1.1	+ .5	+1.4	-1.1	- .6	+ .5	+1.2
	Midseason	16	-1.1	+ .1	+ .9	+ .7	- .6	+ .1	+ .9	+ .7
	Late	15	+ .2	- .6	- .5	- .1	+ .1	- .3	- .5	- .1
	Mean	48	-1.0	- .5	+ .3	+ .7	- .6	- .3	+ .3	+ .6
All varieties	Early	97	- .3	+1.6	+1.2	+ .1	- .2	+ .8	+1.0	+ .1
	Midseason	92	- .7	+ .7	+ .9	+ .4	- .4	+ .3	+ .8	+ .4
	Late	88	+ .2	+1.0	+ .5	- .1	+ .1	+ .6	+ .5	- .1
	Mean	277	- .3	+1.1	+ .9	+ .2	- .2	+ .6	+ .8	+ .1

1/ Conversion of yarn strength was made in all cases by use of the formula reported in publication (2). The average differences shown are based on the respective differences for the individual lots of cotton under consideration. A plus sign indicates that converted yarn strength was greater than actual yarn strength. A negative sign indicates that converted yarn strength was less than actual yarn strength.

2/ Each lot of cotton for a particular variety and date of harvesting represents a different location of growth on cotton improvement group.

3/ Based on mean actual strength of the series of 14s yarn under consideration.

4/ Based on mean actual strength of the series of 22s yarn under consideration.

Table 11.--Comparison of average K values for different ranges in yarn size, representing cottons by variety and date of harvesting, from selected cotton improvement groups, crop year 1948 1/

Variety	Date of harvesting	Lots of cotton 2/	Average K value for yarn sizes of--					Average of K values: (4), (5), and (6)	Difference in K values: (8) - (9)
			14s to 22s	22s to 36s	36s to F. C. 3/	14s to 36s	14s to F. C. 3/		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Acala 1517 (including 2815 and WR) and Acala 4-42	Early	8	9.7	21.9	14.8	17.4	16.0	15.4	+0.6
	Midseason	8	11.4	22.9	16.1	18.7	17.4	16.8	+ .6
	Late	8	17.8	17.5	16.1	17.6	16.8	17.1	- .3
	Mean	24	13.0	20.8	15.6	17.9	16.7	16.5	+ .3
Acala P-18-C	Early	8	17.5	20.2	14.6	19.2	16.8	17.4	- .6
	Midseason	8	21.6	23.4	12.5	22.8	17.4	19.2	-1.8
	Late	8	16.8	21.9	13.8	20.0	17.0	17.5	- .5
	Mean	24	18.6	21.8	13.6	20.7	17.1	18.0	-1.0
Stoneville 2B	Early	11	17.3	17.8	14.0	17.6	15.8	16.4	- .6
	Midseason	11	20.1	17.6	14.1	18.5	16.2	17.2	-1.0
	Late	10	21.4	19.1	15.0	20.0	17.4	18.5	-1.1
	Mean	32	19.6	18.1	14.4	18.6	16.4	17.4	- .9
Rowden	Early	10	21.4	27.9	14.3	25.5	22.3	21.2	+1.1
	Midseason	10	26.8	26.9	12.5	26.8	22.4	22.1	+ .3
	Late	10	22.8	29.4	13.0	27.0	23.1	21.7	+1.4
	Mean	30	23.6	28.1	13.3	26.5	22.6	21.7	+ .9
Deltapine 14	Early	29	24.3	18.4	14.1	20.5	17.3	18.9	-1.6
	Midseason	28	24.9	18.7	14.3	21.0	17.6	19.3	-1.7
	Late	26	23.1	19.4	14.0	20.8	17.4	18.9	-1.5
	Mean	83	24.1	18.8	14.2	20.8	17.4	19.0	-1.6
Coker 100 Wilt	Early	14	28.2	16.5	12.4	20.7	16.4	19.0	-2.6
	Midseason	11	25.6	16.8	13.6	20.0	16.6	18.6	-2.0
	Late	11	23.4	17.1	13.4	19.4	16.5	18.0	-1.5
	Mean	36	25.9	16.8	13.1	20.1	16.5	18.6	-2.1
Miscellaneous varieties	Early	17	25.3	20.8	14.3	22.4	19.4	20.1	- .7
	Midseason	16	23.8	20.3	13.2	21.6	18.0	19.1	-1.1
	Late	15	21.3	23.2	15.2	22.1	19.0	19.6	- .6
	Mean	48	23.6	21.4	14.2	22.0	18.8	19.6	- .8
All varieties	Early	97	22.2	19.9	14.0	20.7	17.7	18.7	-1.0
	Midseason	92	23.0	20.3	13.8	21.3	17.9	19.0	-1.1
	Late	88	21.5	20.9	14.3	21.1	18.1	18.9	- .8
	Mean	277	22.2	20.4	14.0	21.0	17.9	18.9	-1.0

1/ The K value of yarn strength for a cotton ordinarily represents the average decrease in count-strength-product units (break factor) per unit increase in yarn number, as based on the actual strength of two widely different yarn sizes spun from the same cotton, and as discussed in publication (31). For the purpose of this study, however, 6 K values were calculated for each cotton, representing different ranges in yarn size as indicated.

2/ Each lot of cotton for a particular variety and date of harvesting represents a different location of growth or cotton improvement group.

3/ F. C. refers to the finest count or finest yarn size processed from each cotton. It was 60s in 210 cases; 50s in 36 cases; and 44s in 31 cases.

Table 12.--Comparison of statistical values, representing data identified with various independent and dependent variables used in multiple correlation analyses, for 277 cottons from selected cotton improvement groups, crop year 1948

Factors used in analysis, as--	Value for--				
	Mean	Standard deviation	Maximum	Minimum	Range
Independent variables:					
Grade of cotton .... index	98.14	± 5.56	105.	76.	29.
Upper half mean length .... inch	1.04	± .08	1.25	.83	.42
Length uniformity ratio .... index	78.56	± 2.38	93.	72.	21.
Fiber fineness (wt. per in.) .... micrograms	4.23	± .49	5.7	3.1	2.6
Fiber strength .... 1,000 lb. per sq. in.	80.90	± 6.34	98.	70.	28.
Mature fibers (standard method) .... percent	79.00	± 4.54	88.	64.	24.
Dependent variables:					
Strength of 14s yarn converted from 22s 1/ .... pound	188.04	±15.93	243.	151.	92.
Strength of 14s yarn converted from 36s 1/ .... pound	189.46	±18.27	242.	145.	97.
Strength of 22s yarn converted from 14s 1/ .... pound	111.93	± 9.70	143.	91.	52.
Strength of 22s yarn converted from 36s 1/ .... pound	112.65	±11.63	146.	84.	62.
Strength of 14s yarn estimated by csp equation 2/ ...... pound	195.05	±13.45	236.	157.	79.
Strength of 22s yarn estimated by csp equation 2/ ...... pound	117.56	± 8.54	144.	93.	51.
Strength of 36s yarn estimated by csp equation 2/ ...... pound	64.75	± 5.24	81.	50.	31.
Strength of 50s yarn estimated by csp equation 2/ ...... pound	41.64	± 3.77	53.	31.	22.
K factor of yarn strength, 14s to 22s yarn .... csp	22.28	± 7.97	70.5	0.0	70.5
K factor of yarn strength, 22s to 36s yarn .... csp	20.31	± 5.02	34.0	2.3	31.7
K factor of yarn strength, 36s to finest yarn .... csp	14.06	± 2.97	31.0	5.0	26.0
K factor of yarn strength, 14s to 36s yarn .... csp	21.01	± 3.45	37.8	11.4	26.4
K factor of yarn strength, 14s to finest yarn .... csp	17.91	± 2.58	30.1	13.3	16.8
Average of first 3 K factors listed .... csp	18.86	± 2.56	35.8	10.6	25.2

1/ All conversions of yarn strength were made by use of the formula previously referred to, as reported in publication (2).

2/ All estimates of yarn strength were made by use of the 1945-47 count-strength-product equation previously referred to, as reported in publications (13) and (24).

Table 13.—Comparison of statistical values obtained from multiple correlation analysis for six elements of raw-cotton quality with actual and with converted yarn-strength data, representing 277 cottons from selected cotton improvement groups, crop year 1948 1/

Item	Statistical values obtained with yarn-strength data used as the dependent variable representing—					
	Actual strength of 14s yarn	Strength of 14s yarn converted from 22s	Strength of 14s yarn converted from 36s	Actual strength of 22s yarn	Strength of 22s yarn converted from 14s	Strength of 22s yarn converted from 36s
$\bar{R}$	0.871	0.878	0.880	0.878	0.871	0.879
$\bar{R}^2$ x 100 2/	75.9	77.1	77.4	77.1	75.9	77.3
$\bar{S}$ (absolute) 3/ ...	± 7.5	± 7.6	± 8.7	± 4.9	± 4.8	± 5.6
$\bar{S}$ (relative) 4/ ...	± 4.0	± 4.1	± 4.6	± 4.4	± 4.3	± 4.9
Beta coefficients, by rank:						
(1)	U. H. M. length +.725	U. H. M. length +.693	U. H. M. length +.732	U. H. M. length +.693	U. H. M. length +.725	U. H. M. length +.731
(2)	Fiber strength +.381	Fiber strength +.470	Fiber strength +.341	Fiber strength +.470	Fiber strength +.381	Fiber strength +.341
(3)	Fiber wt./in. -.235	Fiber wt./in -.282	Fiber wt./in. -.304	Fiber wt./in. -.280	Fiber wt./in. -.235	Fiber wt./in. -.305
(4)	Grade index +.167	Grade index +.155	Uniformity ratio +.119	Grade index +.158	Grade index +.167	Uniformity ratio +.119
(5)	Uniformity ratio +.140	Uniformity ratio +.105	Grade index +.113	Uniformity ratio +.105	Uniformity ratio +.139	Grade index +.116
(6)	% Mature fibers -.009*	% Mature fibers -.018*	% Mature fibers -.001*	% Mature fibers -.019*	% Mature fibers -.008*	% Mature fibers .000

1/ All conversions of yarn strength were made by use of the formula previously referred to, as reported in publication (2).

2/ Amount of variance explained in actual or converted yarn strength by the 6 elements of raw-cotton quality is expressed in units of percent.

3/ Absolute standard error of estimate ($\bar{S}$) is expressed in units of pounds.

4/ Relative standard error of estimate ($\bar{S}$) is expressed in units of percent, being the absolute value of ($\bar{S}$) divided by the respective mean value of the dependent variable and multiplied by 100.

* Statistically insignificant, being less than 3 times its standard error.

Table 14.--Comparison of statistical values obtained from multiple correlation analysis for six elements of raw-cotton quality with the K factor of yarn strength, representing various ranges of yarn size and 277 cottons from selected cotton improvement groups, crop year 1948

Items	Statistical values obtained with the K factor of yarn strength used as the dependent variable representing--					
	14s to 22s yarn	22s to 36s yarn	36s to finest yarn	14s to 36s yarn	14s to finest yarn	Average of K values: (2), (3), and (4)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\bar{R}$	0.391	0.693	0.149	0.626	0.792	0.523
$\bar{R}^2$ x 100 1/	15.3	48.0	2.2	39.2	62.6	27.4
$\bar{S}$ (absolute) 2/ ...	± 7.4	± 3.6	± 2.9	± 2.7	± 1.6	± 2.2
$\bar{S}$ (relative) 3/ ...	±33.0	±17.9	±20.9	±12.8	± 8.8	±11.6
Beta coefficients, by rank:						
(1)	Fiber strength -.365	U. H. M. length -.464	Fiber wt./in. +.204*	U. H. M. length -.433	Fiber wt./in. +.505	Fiber wt./in. +.422
(2)	Fiber wt./in. +.198*	Fiber strength +.250	Fiber strength +.129*	Fiber wt./in. +.365	U. H. M. length -.473	U. H. M. length -.271
(3)	Unif. ratio +.100*	Fiber wt./in. +.220	U. H. M. length +.086*	Grade index +.086*	% Mature fibers -.114*	Fiber strength -.171
(4)	% Mature fibers +.033*	Unif. ratio -.101*	Grade index -.086*	Fiber strength -.080*	Unif. ratio -.084*	% Mature fibers -.031*
(5)	Grade index +.007*	Grade index +.088*	% Mature fibers -.084*	% Mature fibers -.024*	Grade index +.078*	Grade index +.031*
(6)	U. H. M. length +.003*	% Mature fibers -.059*	Unif. ratio -.084*	Unif. ratio -.008*	Fiber strength +.069*	Unif. ratio +.004*

1/ Amount of variance explained in the K factor of yarn strength by the 6 elements of raw-cotton quality is expressed in units of percent.

2/ Absolute standard error of estimate ($\bar{S}$) is expressed in numerical units of K factor.

3/ Relative standard error of estimate ($\bar{S}$) is expressed in units of percent, being the absolute value of ($\bar{S}$) divided by the respective mean value of the dependent variable and multiplied by 100.

* Statistically insignificant, being less than 3 times its standard error.

Table 15.--Comparison of statistical values obtained from multiple correlation analysis for six elements of raw-cotton quality with estimated yarn-strength data, representing 277 cottons from selected cotton improvement groups, crop year 1948 1/

Items	Statistical values obtained with estimated yarn-strength data used as the dependent variable representing--							
	14s yarn		22s yarn		36s yarn		50s yarn	
$\bar{R}$	1.000		0.999		0.998		0.997	
$\bar{R}^2$ x 100 2/	100.0		99.9		99.7		99.4	
$\bar{S}$ (absolute) 3/	± .3		± .3		± .3		± .3	
$\bar{S}$ (relative) 4/	± .1		± .2		± .4		± .7	
Beta coefficients, by rank:								
(1)	Fiber strength	+.668	Fiber strength	+.669	Fiber strength	+.669	Fiber strength	+.664
(2)	Fiber wt./in.	-.649	Fiber wt./in.	-.647	Fiber wt./in.	-.641	Fiber wt./in.	-.647
(3)	U. H. M. length	+.551	U. H. M. length	+.551	U. H. M. length	+.554	U. H. M. length	+.550
(4)	Uniformity ratio	+.184	Uniformity ratio	+.185	Uniformity ratio	+.178	Uniformity ratio	+.187
(5)	% Mature fibers	+.111	% Mature fibers	+.109	% Mature fibers	+.107	% Mature fibers	+.108
(6)	Grade index	+.017	Grade index	+.017	Grade index	+.017	Grade index	+.021

1/ All estimates of yarn strength were made by use of the count-strength-product equation previously referred to, as reported in publications (13) and (24).

2/ Amount of variance explained in estimated yarn strength by the 6 elements of raw-cotton quality is expressed in units of percent.

3/ Absolute standard error of estimate ($\bar{S}$) is expressed in units of pounds.

4/ Relative standard error of estimate ($\bar{S}$) is expressed in units of percent, being the absolute value of ($\bar{S}$) divided by the respective mean value of the dependent variable and multiplied by 100.

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