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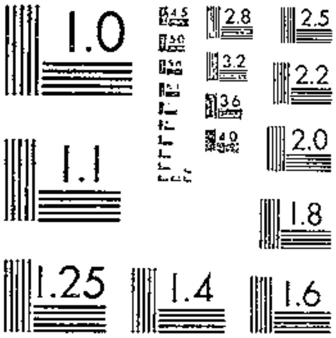

MICROCOPY RESOLUTION TEST CHART
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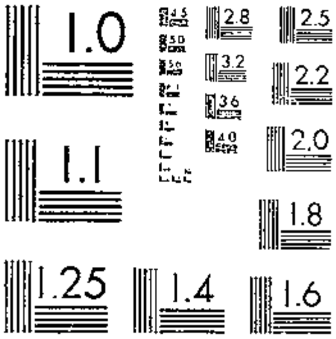

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TECHNICAL BULLETIN No. 396 NOVEMBER 1933

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NEPS AND SIMILAR IMPERFECTIONS IN COTTON[1]

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CONTENTS

INTRODUCTION

To any one concerned with the growing, ginning, marketing, and spinning of cotton, neps constitute a problem of great importance, for the presence of these tangled knots of fibers in ginned lints and yarns influences the quality and value of these materials. The presence of neps in the yarn is a serious problem. When woven into cloth, a neppy yarn produces a fabric with many imperfections. Frequently the neps do not dye properly and therefore appear as light specks on a dark background (pl. 1, G); or, even if properly dyed, they produce irregularities that may be very conspicuous (pl. 1, H and I).

In order to spin a yarn of good quality as economically as possible, it is necessary that the manufacturing machinery be in good condition, properly adjusted, and efficiently operated. It is equally necessary that the cotton lint selected be of high spinning quality, and neps are one of several factors determining the spinning quality, and therefore the value, of raw cotton.

A neppy lint presents many problems to the cotton manufacturer. If the neps are not to appear in the finished yarn, they must be removed and their removal is difficult and frequently impossible to accomplish. Moreover, the attempts to extract neps during the carding and combing processes remove, at the same time, a certain quantity of good fiber, thus increasing the percentage of visible

[1] This study is one of a series in the program of work of the Cotton Utility and Standards Research Section under the leadership of R. W. Webb.

[2] Appreciation for samples and information is expressed to F. L. Gardes and to M. E. Campbell, respective leaders of the section's ginning and spinning projects; to G. L. Crawford, leader of the division's southwestern irrigated cotton quality project; and to C. A. Bennett, engineer in charge at the experimental gin of the Bureau of Agricultural Engineering.

waste and the cost of production. In addition, neps may be more or less responsible for the end breakage that occurs during spinning. The resulting machine stoppage entails an increase in labor costs.

Neppiness in ginned lint is one of several quality elements involved in the standardization and utilization of cotton that are induced by ginning or its associated processes. Neps in ginned lint are usually considered evidence of bad ginning practices. Poorly ginned lint is described as having "poor preparation" or as being "gin damaged." Gin-damaged cotton is very undesirable. It contains excessive waste and presents manufacturing difficulties, thereby increasing production costs. Moreover, the yarn that is finally produced is likely to be irregular and weak.

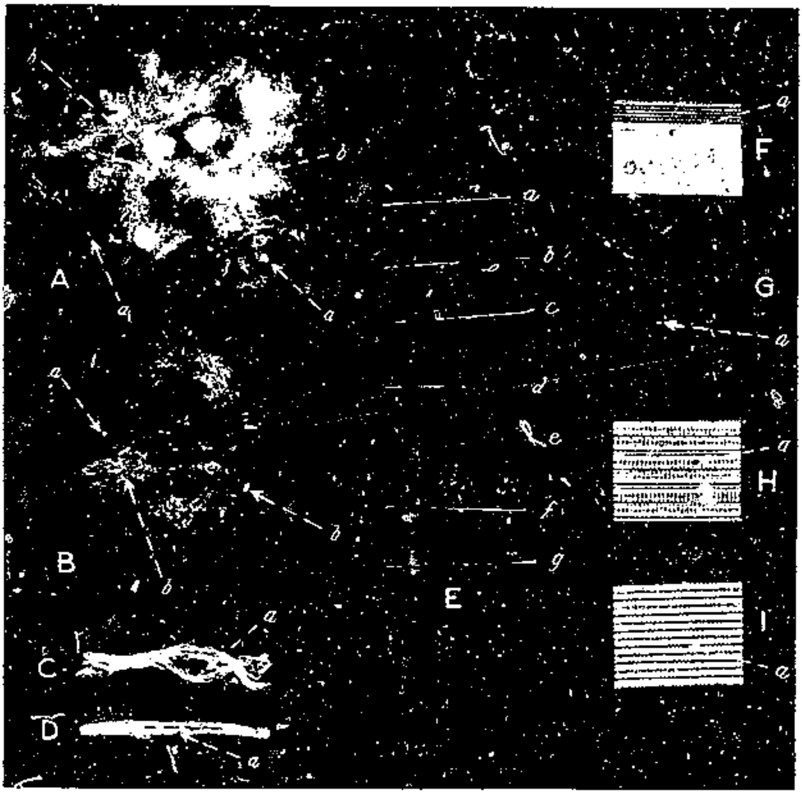
Recent complaints made to the Department of Agriculture and elsewhere, by foreign and domestic manufacturers, allege that neppiness and poor preparation occur in American cotton more often than is necessary. These complaints concerning the quality of the American cotton crop, together with a need for more definite and extensive knowledge concerning the quality elements involved in the standardization of cotton for marketing purposes, impelled the Department of Agriculture to take the necessary steps to obtain all possible information pertaining to cotton quality and its improvement. The cotton-ginning investigations of the Department, the major responsibilities of which are handled jointly by the Bureaus of Agricultural Engineering and Agricultural Economics, have been designed to obtain basic information that would be of assistance in formulating ways and means of improving the quality of the American cotton crop through the processes of conditioning, extracting, cleaning, and ginning (*15*).[3] An extensive study of neps and neplike structures has been undertaken as a fundamental part of the experimental ginning program.

Apparently, neps are first formed in appreciable quantities during the ginning of the cotton but they may be decreased or increased in number during the process of converting raw cotton into yarn. There are many opinions as to how and why neps develop. Certain types of cotton are characterized as being inherently "neppy" (*4*, *16*). In fact, there is a fairly popular opinion that neps occur in seed cotton.[4]

It is thought, too, that environmental conditions play an important part in determining the predisposition of a cotton to form neps (*2*, *pp. 4–5*; *3*, *5*, *12*). The criticism has been made, moreover, that certain methods of conditioning, cleaning, and ginning nep the cotton (*3*, *4*, *5*, *12*, *23*). The process of carding, which in general is expected to rid the lint of neps, actually adds many (*6*), the number being influenced by the adjustments and condition of the card (*3*, *11*). And, according to studies made on slivers, rovings, and yarns, still more neps may be added to the cotton as it passes through the machines previous to actual spinning (fig. 1).

[3] Italic numbers in parentheses refer to Literature Cited, p. 17.

[4] Although examinations of seed cotton have been insufficient to justify the statement that neps do not occur, the present investigation has brought forth no evidence to support a view that neps do occur to any important extent in seed cotton before it is handled. Many locks from both irrigated and rain-grown varieties of cotton have been examined, and although tiny tangles could be found after a slight manipulation of the fibers with the fingers, it is questionable whether these tangles existed before manipulation. Balls (*6*, *p. 19*) states that "nep does not exist in the living boll, but is made by handling, by ginning, and especially by the carding machine, from hairs with unduly thin walls." He does admit, however, the possibility of neps being formed "even without handling, in the act of drying, on the plant in the field."



A, Ginned lint showing neps *a*, and fragments of seed coat *b*. B, Portion of card sliver separated to show neps *a* and seed-coat fragments *b*. C, Portion of fine frame roving containing a nep *a*. D, Portion of fine frame roving containing a fragment of seed coat *a*. E, Pieces of yarn with neps *e*, *f*, and *g*, and seed-coat fragments *a*, *b*, *c*, and *d*. F, Cloth with a conspicuous fragment of seed coat *a*. G, Cloth with neps that did not dye (light specks, *a*). H and I, Cloth with conspicuous dyed neps *a*. All figures two-thirds natural size.

Therefore, it would appear that the neps present in a given sample may be the result of the combined influence of at least two main factors: The specific characteristics of the particular cotton and the type of treatment it has received.

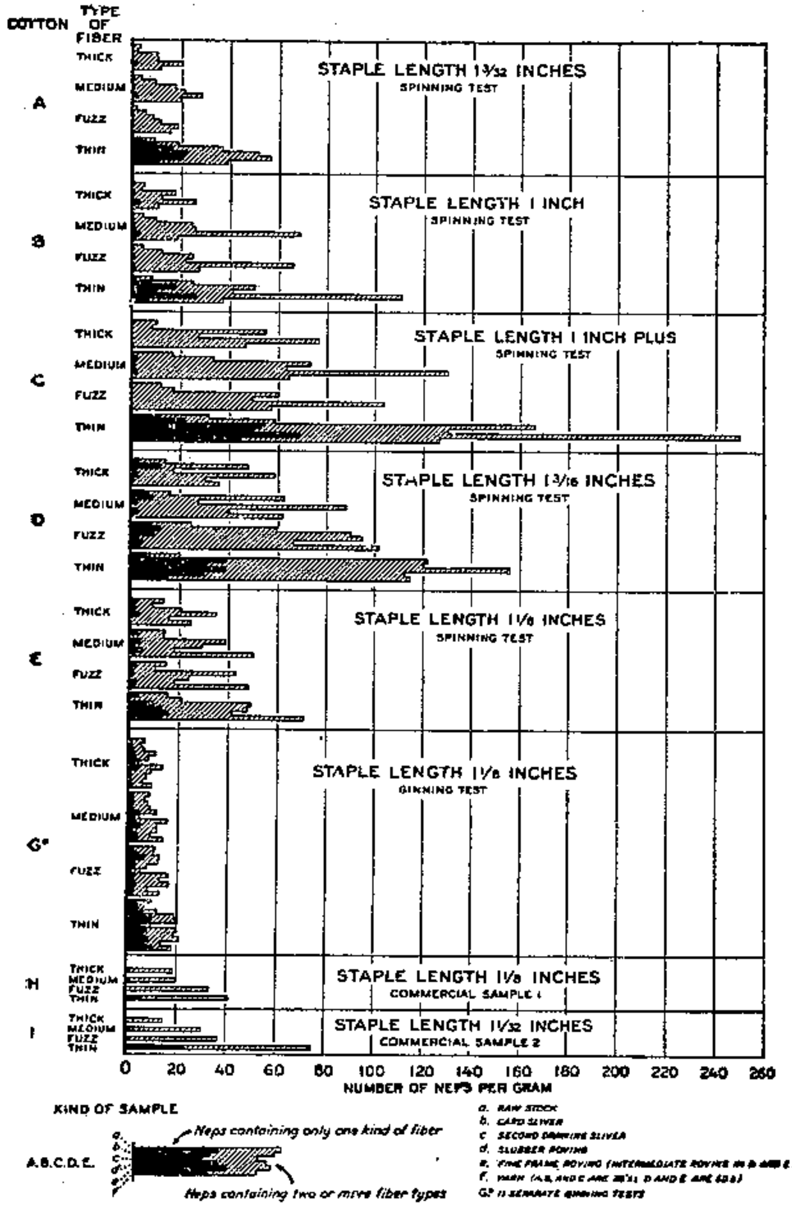


FIGURE 1.—Number of neps per gram into which each fiber type enters. In general, the thin-walled fibers enter into the greatest number of neps and thick-walled fibers into the least, neps that possess medium-walled or fuzz fibers being intermediate in number. The thin-walled fibers knot up alone into neps much more readily than do the medium-walled, thick-walled, or fuzz fibers. The number of neps appears to be increased during the manufacturing processes.

In addition to the tangled knots of fibers there occur in ginned lints, slivers, rovings, and yarns other small particles that are similar to neps in size and general appearance and are equally undesirable. The exact nature of these small imperfections frequently can be ascertained only by means of a microscopic examination. Since in general usage the term "nep" designates only small tangled knots of fibers (*17*), these structures are not, strictly speaking, neps. It is true that occasionally in a discussion of neps, structures other than the small fiber tangles are included under the term. Summers, for example (*24, p. T325*), considers neps in yarn to be all those faults that are due to the presence "of any fiber or material other than the normal cotton fiber." Midgley (*18*) designates as " 'fuzz' neps" tiny fragments of seed coat with the attached fuzz fibers. It is questionable whether or not the neplike structures should be included under the term "nep", but their inclusion along with a general consideration of neps seems reasonable since they resemble neps in size and general appearance and they are present in ginned lints as a result of conditions existing in the seed cotton; moreover, the numbers of certain of these particles occurring in ginned lint appear to be influenced to a certain extent by methods of conditioning and ginning the seed cotton.

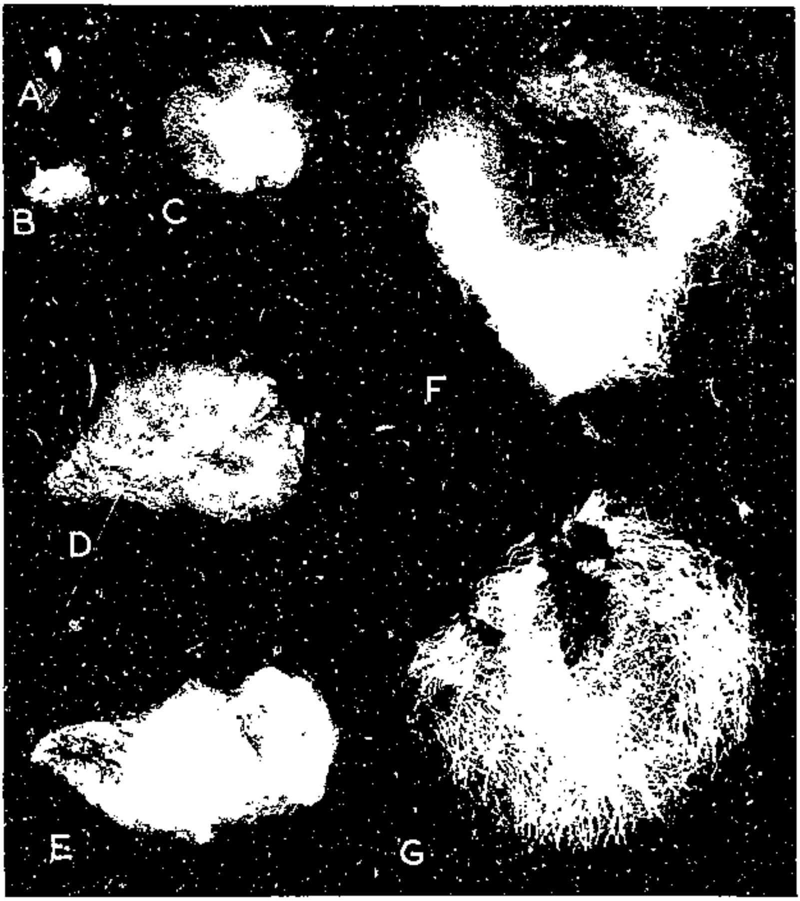
A thorough study of neps involves a consideration of two problems: (1) The type of neps and similar imperfections that may be formed in cotton during its ginning and its manufacturing into yarn and (2) the relationship of the types and their abundance, (*a*) to specific characteristics of the seed cotton, and (*b*) to the action of different machines, organizations, and practices employed during commercial and experimental ginning and spinning.

The present discussion concerns itself primarily with a description and classification of the neps and neplike structures that have been found in ginned lints, in certain intermediate products of its manufacture, and in yarns; and with a general consideration of some of the factors that may play a part in the formation of such small but objectional structures and imperfections.

MATERIALS AND METHODS

The greater part of the materials used for this study consisted of: Ginned lints from ginning tests that had been performed at the experimental ginning plant of the United States Department of Agriculture, Stoneville, Miss.; raw stocks, slivers, rovings, and yarns from spinning tests which were made by the Bureau of Agricultural Economics, United States Department of Agriculture, in cooperation with the Textile Department at Clemson College, South Carolina; and a few commercial samples that were submitted to the laboratory for analysis.

The detailed data presented in this discussion are derived from a study of nine cottons, designated as A, B, C, D, E, F, G, H, and I; the lints of these cottons had been classed according to staple length as 1 3/32, 1, 1+, 1 3/16, 1 1/8, 1 1/16, 1 1/8, 1 1/8, and 1 1/32 inches, respectively. Cottons A, B, C, and F are Acala cottons that were grown in the irrigated section of the Southwest; cottons D, E, and G are rain-grown varieties of upland cotton; cottons H and I are from samples of two commercial cottons grown in the irrigated section of the Southwest, that were submitted to the laboratory for analysis.



A, B, C, Motes, four-fifths natural size. D, Lock of cotton with compressed mat of fibers, four-fifths natural size. E, Lock showing diseased area, four-fifths natural size. F, Portion of a seed showing the fragmentation of the chalazal end of the seed, × 7. G, Fragment from the chalazal end of the seed coat with attached fibers, × 7.

The detailed studies were carried out upon small portions selected from large samples of lints, slivers, rovings, and yarns that had been sent to the laboratory for analyses. The small samples of ginned lints were made by taking small pulls from 12 places on the large laboratory sample, the resulting composite sample weighing from 3 to 5 grams; samples for the study of slivers and rovings were made by taking short lengths from several places on the large laboratory sample, the selected portions usually weighing from 0.5 to 2.0 grams. All selected samples were conditioned at 70° F. and 65 percent relative humidity for at least 24 hours, and were then weighed. Each sample was carefully teased apart with forceps, and all small definite fiber knots or small particles other than bits of foreign matter were picked out and the adhering fibers were carefully pulled away; the remaining structures were then examined microscopically and classified (table 1, p.9). Yarn was examined as it was unwound from the bobbin; after being examined, the studied portions were conditioned and weighed. The yarn was not unraveled, and only the neps and similar imperfections that appeared on the surface or that were sufficiently large to cause a bulge, were examined and counted.

The neps were classified according to the types of fibers that entered into their composition, which method of classification will be discussed in detail later. The data obtained were used to estimate the importance of different fiber types in nep formation and to calculate the number of neps and similar structures per gram of material examined.

OBSERVATIONS AND DISCUSSION

The classification of neps and similar structures developed as a result of this study has been entitled, for lack of a more inclusive term, a "nep classification." Thus the phrase "total nep content" includes the neplike structures as well as the tangled knots of fibers. However, for discussional purposes, the term nep[5] is applied to small aggregates of fibers tangled together to a degree that is sufficient to allow the entire knot to be separated from the surrounding fiber mass.

GENERAL CLASSIFICATION OF SMALL IMPERFECTIONS

The majority of the small imperfections occurring in ginned lints, slivers, rovings, and yarns can be divided into two definite groups: Neps proper—which consist only of entangled fibers (pl. 3, L) and fragments of seed coat with the fibers still attached (pl. 4, H). A small percentage of the imperfections fall outside these two groups. Occasionally knots are found that have been made by long fibers becoming tightly twisted around tiny fragments of seed coat or around bits of foreign matter such as leaf trash or the stellate hairs from the surface of the cotton plant. Other small particles have been found to be fragments from brittle, compressed fiber masses (pl. 2, D; pl. 3, B) or from dried, diseased areas, (pl. 2, E; pl. 3, A).

All of these imperfections have originated in some manner from the seed cotton itself; no foreign matter is included except the small particles around which fibers may have become tightly knotted.

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[5] A distinction is made between neps and naps, the term "nap" being used to designate the large clumps or matted masses of fibers occurring in ginned lint (*12*, *15*).

NEPS PROPER

COMPOSITION AND CLASSIFICATION

It is the current opinion that neps are made up chiefly of thin-walled fibers. Balls (*6*), Bowman (*7*), Butterworth (*8*), Clegg (*9*), Clegg and Harland (*11*), Monie (*19*), and Walen (*25*), observed that neps consist largely of thin-walled fibers with occasional mature or thick-walled fibers entangled with them. In the study here reported several thousand neps were examined, and although thin-walled fibers appeared most abundantly in the knots, other types of fibers were found to be entangled also (pl. 4, A, B, C, and F). As a result of these observations it was concluded that a workable scheme for classifying neps could be developed by using the type or types of fibers entering into the composition of the individual neps as a basis for the classification.

To develop such a scheme it was necessary to decide upon a system for classifying the types of fibers that may be found in neps. A study of the fibers occurring on the seed and in the ginned lints of several cottons showed that it would be impracticable to attempt to make exact measurements for the purpose of classifying the fibers, but that it would be possible to divide roughly into three groups the bulk of the fibers that are removed from the seed by ginning, using as a basis for this division the degree to which the thickening of the secondary wall has taken place. This degree of thickening is defined by Peirce (*21, p. 9*) as the "wall thickness divided by the radius."

Classifying fibers according to thickness of fiber wall is the method most commonly used, although the classes have been variously named. For example, the Shirley Institute (*1, p. 97*) terms the three divisions normal cotton, thin-walled cotton, and immature or "dead" cotton. In this study the three groups are designated as: Thick-walled fibers, medium-walled fibers, and thin-walled fibers. In general, the thick-walled fibers have walls relatively thick in proportion to the ribbon width and have well-defined convolutions (pl. 3, K). Thin-walled fibers are usually transparent and ribbonlike, possessing little or no secondary wall deposition (pl. 3, H and I). Fibers that are intermediate between these two extremes as regards wall thickness constitute the intermediate group, or medium-walled fibers (pl. 3, J).[6]

Fuzz fibers constitute another fiber type. These fibers are short and usually very thick-walled, irregularly turned, and twisted (pl. 3, G). They occur in various proportions on the seeds of most varieties of cotton, and their number in ginned lint is determined not only by the number originally present on the seed but by the closeness with which the cotton is ginned. They may be found in neps and therefore are here considered as forming a fourth fiber group.

It is realized that this classification does not represent four well-defined groups and that consequently it is a matter of personal opinion into which division a given fiber should be grouped. It is not within the province of this bulletin to consider the methods employed by various investigators to measure and define the degree of fiber

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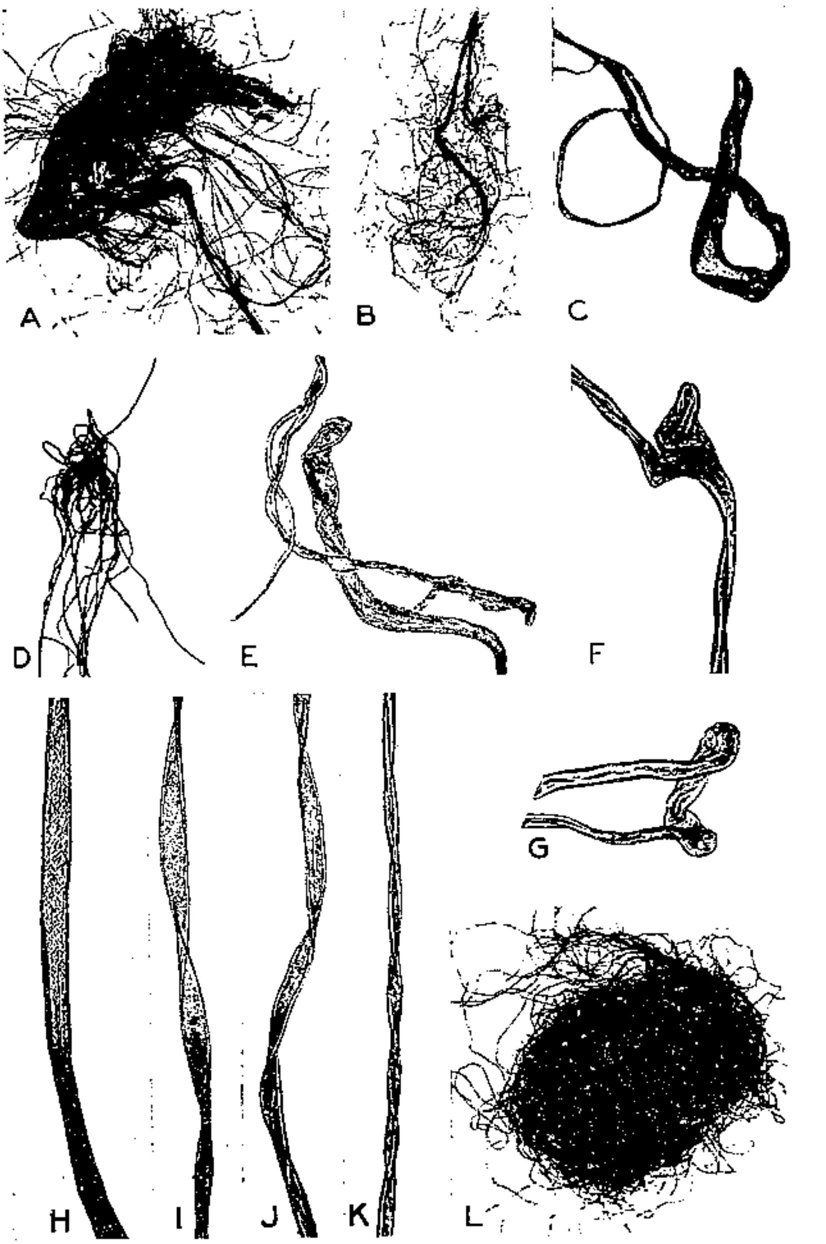
[6] Since the border-line cases between the thick-walled and medium-walled fiber groups are the most difficult to classify, a number of fiber measurements were made to aid in establishing a "mental standard" for these two groups of fibers. Fibers from cottons representing several staple lengths were measured. Although sufficient measurements have not been made to justify the establishment of a fiber classification. based on exact fiber measurements, in general, it was found that fibers classed as thick-walled possessed a ratio of 3 to 1 or less between the ribbon width and the combined thickness of the two walls as measured at the widest portion between two twists.



A, Fragment from a diseased area (pl. 2, E) in ginned lint, × 9. B, Mass of compressed thin-walled fibers in ginned lint, × 9. C, Abnormality, × 53. D, Nep from second drawing frame sliver, × 27. E, Abnormality, × 62. F, Abnormality, × 120. G, Portion of a fuzz fiber, × 117. H, Portion of a thin-walled fiber from a mote, × 117. I, Portion of a thin-walled fiber from a mature seed, × 117. J, Portion of a medium-walled fiber, × 117. K, Portion of a thick-walled fiber, × 117. L, Nep from ginned lint, × 9.

maturity as represented by the thickness of the secondary wall. The purpose, here, is to present a simple outline for classifying rapidly the types of fibers that may be found in neps. Enough fibers and neps from various cottons were examined, however, to justify the conclusion that, for the purposes of this problem, this classification is sufficiently accurate.

Using these four fiber types as a basis, the following scheme of classification was developed, 15 kinds of neps being differentiated according to the type or types of fibers that enter into the tangle.

NEP CLASSIFICATION

- Neps proper—entangled fibers only:
  - Thick-walled fibers only
  - Medium-walled fibers only
  - Thin-walled fibers only
  - Fuzz fibers only
  - Thick- and medium-walled fibers
  - Thick- and thin-walled fibers
  - Medium- and thin-walled fibers
  - Thick-, medium-, and thin-walled fibers
  - Thick-walled and fuzz fibers
  - Medium-walled and fuzz fibers
  - Thin-walled and fuzz fibers
  - Thick- and medium-walled and fuzz fibers
  - Thick- and thin-walled and fuzz fibers
  - Medium- and thin-walled and fuzz fibers
  - Thick-, medium-, and thin-walled and fuzz fibers
- Fragments of seed coat:
  - Fragments of mature seeds
  - Fragments of motes
- Fragments of seed coat and entangled fibers
- Foreign matter and entangled fibers
- Fragments from compressed fiber masses
- Fragments from dried diseased areas

The number of fibers of each type entering into a nep is not considered in the scheme. Such information would be desirable, but it was found to be practically impossible to separate the individual fibers and be certain that none of them was broken in the process. Moreover, a consideration of fiber numbers would result in an unwieldy system of classification. Therefore, a nep that contained many thin-walled fibers and a few fuzz fibers was classified no differently from one containing many fuzz fibers and only a few thin-walled ones.

Although the classifications of fibers and neps here described are based on observations made on a limited number of cottons, it is reasonable to suppose that they may be applied to most cottons. By using this nep classification in the study of a particular cotton it should be possible to learn what relationship, if any, the number and type of neps developed bears (1) to the proportions in which the various fiber types occur on the seed, and (2) to such measurable properties of the fibers as length, fineness, etc.

Certain investigators have attempted to distinguish between the type of nep that is formed during ginning and the type developed during the manufacturing of yarn. Bowman (*7*) and Monie (*19*) consider two classes of neps: Natural neps which occur in ginned lint and artificial neps which are produced during the manufacturing processes. Bowman (*7*) describes the natural neps as consisting of short, comparatively whole, thin-walled fibers, whereas the artificial neps are made up of fiber fragments. Monie (*19*, p. *131*) states that when immature fibers are removed from the seed "they contract, curl up, and in this condition entwine and firmly attach themselves to the good fiber" forming "white specks or excrescences on the surface of the fibers." These excrescences he terms "natural 'neps'." No illustrations are given and it is difficult to interpret exactly what is meant. He does not discuss the structure of artificial neps.

Summers (*24*, p. T*325*), in discussing neps in yarn excludes "the so-called 'nep' formed in the card from normal cotton by faulty setting and grinding."

Walen (*25*) describes the neps of yarn as being smaller, harder, and tighter tangles than are those occurring in the bale or in the picker lap.

It is to be expected that the neps produced during the manufac turing of yarn will possess more broken fibers than will the neps occurring in ginned lint, for many of the weak fibers are broken during the carding and drawing processes. It is also true that neps in ginned lint are, on the whole, larger and somewhat more loosely knotted than are the neps in yarn; yet many neps may be found in the lint which are impossible to tease apart without breaking the fibers. Nevertheless, the present studies give little or no basis for concluding that there is any essential difference between the neps occurring in ginned lint and those found in the products of the manufacturing processes.

SOME FACTORS AFFECTING NEP FORMATION

The following discussion does not attempt to cover in detail the subject of factors affecting nep formation, but rather to consider briefly some points regarding the formation of neps that were brought out in the study of neps in these particular cottons. To what extent the conclusions derived from these observations may be true also of other cottons can be determined only by applying a similar method of study to those cottons.

One of the points most strikingly brought forth as a result of this study is the relative importance of the various fiber types in nep formation.

All the neps occurring in the samples studied were examined microscopically and were classified according to the kind or kinds of fibers that entered into their composition; that is, they were classified as to whether they consisted of thin-walled fibers alone, thick-walled and thin-walled fibers, thin-walled and fuzz fibers, etc., each different fiber combination being considered a nep type (Nep classification, p. 7). For each sample the number of nep types was counted and the data were used to ascertain the number of neps into which each kind of fiber entered (table 1). This number was obtained by counting every nep that included the fiber type in question, either alone or in combination with other types of fibers. Consequently, neps composed of more than one fiber type were counted once for every type of fiber entering into the tangle; for example, a nep composed of both thin-walled and fuzz fibers was counted once as a nep containing thin-walled fibers and again as a nep containing fuzz fibers.

The numbers per gram of neps containing each fiber type as well as the numbers per gram of neps composed only of one fiber type were then calculated.

TABLE 1.—*Laboratory analysis of the nep content of a cotton sample*

[Number of sample, 14; kind of sample, yarn; weight of sample, 2.2761 grams]

ANALYSIS OF TOTAL NEP CONTENT

Nep type	Neps in sample	Neps per gram	Percentage of total nep content
Neps proper:			
Thick-walled fibers only	1		
Medium-walled fibers only	1		
Thin-walled fibers only	14		
Fuzz fibers only	2		
Thick- and medium-walled fibers	0		
Thick- and thin-walled fibers	1		
Medium- and thin-walled fibers	11		
Thick-, medium-, and thin-walled fibers	3		
Thick-walled and fuzz fibers	3		
Medium-walled and fuzz fibers	2		
Thin-walled and fuzz fibers	20		
Thick-, medium-walled, and fuzz fibers	0		
Thick-, thin-walled, and fuzz fibers	10		
Medium-, thin-walled, and fuzz fibers	19		
Thick-, medium-, thin-walled, and fuzz fibers	6		
Total	93	40.86	67.39
Fragments of seed coat:			
Fragments of mature seeds	39		
Fragments of motes	3		
Total	42	18.45	30.43
Fragments of seed coat and entangled fibers	0		
Foreign matter and entangled fibers	0		
Fragments from compressed fiber masses	1	.44	.72
Fragments from dried diseased areas	2	.88	1.45
Total	138		

ANALYSIS OF "NEPS PROPER" [1]

Nep type	Neps in sample	Neps per gram	Percentage of "nep proper" content
Neps containing thick-walled fibers:			
Thick-walled fibers only	1	0.44	1.08
Thick- and medium-walled fibers	0		
Thick- and thin-walled fibers	1		
Thick-, medium-, and thin-walled fibers	3		
Thick-walled and fuzz fibers	3		
Thick-, medium-walled, and fuzz fibers	0		
Thick-, thin-walled, and fuzz fibers	10		
Thick-, medium-, thin-walled, and fuzz fibers	6		
Total	24	10.54	25.81
Neps containing medium-walled fibers:			
Medium-walled fibers only	1	.44	1.08
Thick- and medium-walled fibers	0		
Medium- and thin-walled fibers	11		
Thick-, medium-, and thin-walled fibers	3		
Medium-walled and fuzz fibers	2		
Thick-, medium-walled, and fuzz fibers	0		
Medium-, thin-walled, and fuzz fibers	19		
Thick-, medium-, thin-walled, and fuzz fibers	6		
Total	42	18.45	45.16
Neps containing thin-walled fibers:			
Thin-walled fibers only	14	6.15	15.05
Thick- and thin-walled fibers	1		
Medium- and thin-walled fibers	11		
Thick-, medium-, and thin-walled fibers	3		
Thin-walled and fuzz fibers	20		
Thick-, thin-walled, and fuzz fibers	10		

[1] Number in sample, 93.

6917°—33——2

TABLE 1.—*Laboratory analysis of the nep content of a cotton sample*

ANALYSIS OF "NEPS PROPER"—Continued

Nep type	Neps in sample	Neps per gram	Percentage of "nep proper" content
Neps containing thin-walled fibers—Continued.			
Medium-, thin-walled, and fuzz fibers	19		
Thick-, medium-, thin-walled, and fuzz fibers	6		
Total	84	36.91	90.32
Neps containing fuzz fibers:			
Fuzz fibers only	2	.88	2.15
Thick-walled and fuzz fibers	3		
Medium-walled and fuzz fibers	2		
Thin-walled and fuzz fibers	20		
Thick-, medium-walled, and fuzz fibers	0		
Thick-, thin-walled, and fuzz fibers	10		
Medium-, thin-walled, and fuzz fibers	19		
Thick-, medium-, thin-walled, and fuzz fibers	6		
Total	62	27.24	66.67

In figure 1 are presented the results derived from an examination of 43 samples representing 5 spinning tests on 5 different cottons (A, B, C, D, and E), 11 samples representing 11 ginning tests on a sixth cotton (G), and 2 commercial samples submitted to the laboratory for analysis (H and I). The figure shows that, in general, the thin-walled fibers enter into the greatest number of neps and the thick-walled fibers into the least; the number of neps possessing medium-walled or fuzz fibers are intermediate in number. When calculations were made to ascertain the percentage of neps possessing any one of the fiber types, it was found that in 61 out of 83 samples from 80 to 100 percent of the neps contained thin-walled fibers. In only 4 cases did the percentage fall below 50.

Figure 1 also shows that the number of neps composed only of thin-walled fibers greatly exceeds the number formed by any one of the other fiber types alone. The medium-walled and fuzz fibers are seen to become entangled alone somewhat more readily than do the thick-walled fibers.

The abundance of fuzz fibers in neps undoubtedly is due largely to their twisted irregular shapes; but that any one definite crook or twist results in the entanglement of other fibers has been found true only in small neps and cannot be demonstrated satisfactorily there. In spite of their irregular shapes, fuzz fibers alone do not form readily into tight neps. These fibers may occur in definite small masses, in the ginned lint especially, but the individual fibers usually can be separated readily with dissecting needles. If only a very few thin-walled fibers become entangled with them, however, a very tight nep may be formed.

Thick-walled fibers alone form very few neps, and many of those that do develop are made by the knotting together of the long, slender, tapering tips.

From these observations it may be concluded that the thin-walled fibers are the most important type in nep formation. The fact that the thin-walled fibers enter into the largest proportion of the neps occurring in a sample together with the fact that the thick-walled, medium-walled, and fuzz fibers demonstrate little tendency to knot up alone, indicates that in the majority of neps it is the thin-walled fibers that form the basis of the entanglement.

It is the inability of these thin-walled fibers to dye properly that gives so much trouble to the dyers. It has been recognized for many years that certain fibers will not dye but remain white and result in streaks or specks in the cloth. M. Daniel Koechlin-Schauch was the first to suggest, in 1848, that unripe fibers might be responsible for this defect (*11, 13*). Crum (*13, 14*) investigated the problem and found the light streaks and specks to consist of "dead" or unripe cotton. The problem was investigated later by Clegg and Harland (*11*), who likewise found that the light streaks and specks in alizarin-dyed fabrics were due to neps composed of thin-walled fibers.

Since it has been shown that thin-walled fibers are generally the basis of nep formation, it would be expected that the number of thin-walled fibers a cotton possesses would determine, in part at least, the number of neps that would be developed during ginning and manufacturing into yarn. Table 2 shows that, in general, there is a tendency for the cottons possessing the largest percentage of thin-walled fibers to have also the largest number of neps.[7] The data are not entirely consistent in this respect. A partial explanation for the discrepancies probably lies in the fact that all of the lints have not had identical treatment and undoubtedly do not possess similar fiber properties.

TABLE 2.—*Relationship between the percentage of thin-walled fibers in 8 lots of cotton and the number of neps developed during the ginning processes*

Cotton	Staple length	Thin-walled fibers in raw cotton	Neps per gram in raw cotton	Cotton	Staple length	Thin-walled fibers in raw cotton	Neps per gram in raw cotton
	Inches	*Percent*	*Number*		*Inches*	*Percent*	*Number*
A	1 3/32	27.02	8.84	E	1⅛	32.36	31.46
B	1	24.64	8.8	G [1]	1⅛	20.35	13.67-36.30
C	1+	28.35	32.92	H	1⅛	40.76	44.7
D	1 3/16	32.41	45.25	I	1 5/32	37.08	76.23

[1] 11 ginning tests.

That factors other than the number of thin-walled fibers a cotton possesses may influence the number of neps produced is brought out in figure 1 and table 2. The number and kinds of neps are seen to vary considerably among the different tests and samples studied. A certain degree of this variation results from the difficulty met in deciding exactly how small or how definite a tangle must be before it is considered a nep. This is especially true in ginned lint, in which there frequently occur fiber knots that are considerably larger than any of the neps found in slivers, rovings, or yarns. When such masses were more than 4 or 5 times as large as the average sized neps found in slivers or rovings, they were not considered.

The problem is complicated further by the facts that a truly representative sample is probably impossible to obtain and that personal judgment is used in deciding the types of fibers that consti-

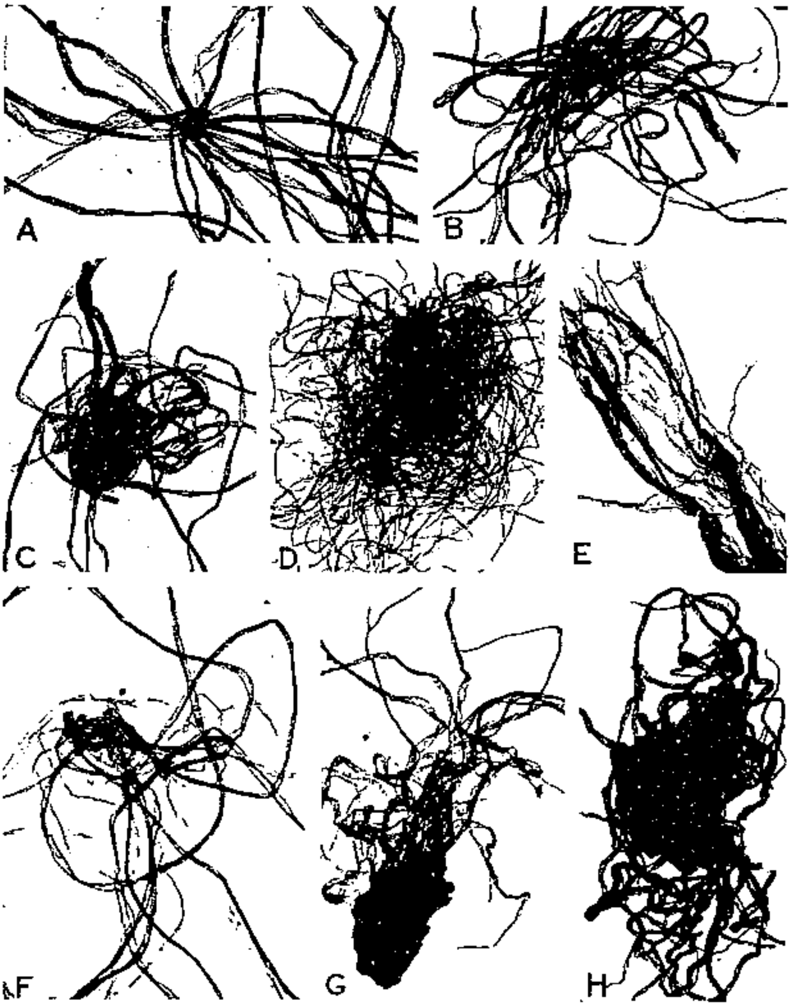
[7] With the exception of sampling, the method employed in determining the percentage of thin-walled fibers is the same as that described by Clegg (*10*). The percentages are based on observations made on about 2,000 fibers, 200 being selected from each ⅛-inch interval from the length array beginning at the ¼-inch group. The laboratory determinations were made by the Cotton Fiber Research Laboratory and thanks are due to T. L. W. Bailey, Jr., and his coworkers for their cooperation in securing the data.

tute any given nep. Nevertheless, there are some fairly consistent variations in the number of neps found in certain of the samples. These variations may be due to fundamental differences in the cottons themselves or to differences in the treatment they have received. As it is not within the province of this bulletin to discuss in detail the behavior of definite lots of cottons as regards nep formation, these differences in nep content and their possible significance can be indicated only.

Cottons A, B, and C are southwestern irrigated Acala cottons that were grown and spun as part of the work of the project concerned with the southwestern irrigated cotton quality problem. Cottons B and C are the same strain; A is a strain derived from the same stock as B and C but differing from them in possessing seeds with much less fuzz. The ginning and spinning history of the three are the same. Cotton C is seen to be the neppiest of the three and yet its history differs from that of B principally in the fact that it was grown on poor land whereas B was grown on good land. The slightly larger number of thin-walled fibers possessed by C does not seem to be sufficient to account for the great difference in nep content. The greater neppiness of C may result in part from characteristics developed in the seed cotton as a result of unfavorable growth conditions, which characteristics in some way either increase the readiness with which the fibers become entangled into neps or increase the difficulty with which the fibers are removed from the seed in ginning. It is true that cotton C was classed as longer than cotton B, but the difference in length seems too slight to be correlated with the degrees of neppiness of the two cottons.

Cottons A and B, representing two strains which apparently differ chiefly in the quantity of fuzz fiber produced, were grown under fairly comparable soil and weather conditions. Although there is little difference in the nep content of the lints of the two cottons, nep counts on the slivers, rovings, and yarns show that, on the whole, A is less neppy than B, and yet it possesses a larger percentage of thin-walled fibers, and is longer. Evidently, the difference in the number of neps developed during the manufacturing of yarn may be attributed to other differences in the cottons. The fact that the seeds of A have less fuzz than the seeds of B may be one limiting factor, for it has been demonstrated that fuzz fibers may play a certain part in nep formation (p. 10) and A has been shown to possess not only fewer neps than B but also fewer neps containing fuzz fibers (fig. 1). In addition, cotton A was found to gin very easily; the readiness with which the fibers were removed from the seed would result in less roping and stringing of the lint than would occur if the fibers clung tenaciously to the seed coat. Consequently the lint would be in a condition less conducive to the development of small tangles during the processes preparatory to spinning the cotton into yarn.

Cottons D and E are two upland rain-grown varieties. They received the same treatment during ginning and spinning and both were found to possess about equal numbers of thin-walled fibers, yet D is considerably neppier than E. Here, too, the number of thin-walled fibers alone cannot account for the number of neps developed. It is possible that the number of neps may be related to the staple length of the two cottons, for cotton D, which is the neppier, is a longer and therefore finer cotton than cotton E.



A, Small nep composed of thick-walled, medium-walled, and thin-walled fibers; second drawing frame sliver, × 57. B, Nep made up of thick-walled, medium-walled and thin-walled fibers; yarn, × 40. C, Nep consisting of thin-walled and fuzz fibers; yarn, × 40. D, Nep consisting of thin-walled fibers only; ginned lint, × 28. E, Mass of greatly compressed thin-walled fibers, second drawing frame sliver, × 23. F, Nep composed of thin-walled and medium-walled fibers; card web, × 40. G, Fragment of mote; yarn, × 40. H, Fragment of mature seed, yarn, × 40.

However, when cottons H and I are compared, the shorter cotton is seen to be the neppier. Since the complete histories of these two cottons are not known, no attempt can be made to explain the fact that cotton I is neppier than cotton H.

Thus it may be concluded that, although the proportions in which the various fiber types occur on the seed influence the number of neps produced, there are other properties of the seed cotton which are factors influencing the number of neps developed during the ginning and manufacturing processes.

Studies now being conducted indicate that different methods of ginning procedure affect to different degrees the neppiness of the resulting ginned lints (fig. 1, cotton G). It is clear (fig. 1) that the continued manipulation of the fibers during the carding and manufacturing of yarn may increase the number of neps,[8] but the percentages of neps possessing each fiber type are not altered greatly. Carding seems to decrease somewhat the percentage of neps possessing thick-walled and fuzz fibers, but the later processes may increase these percentages.

Many neps were teased apart in order to ascertain whether the manner in which the fibers are entangled would give any indication as to the way in which the neps were formed. But no definite methods of fiber knotting were observed. A large nep is usually merely a tangled mass of fibers with no definite center (pl. 4, D), whereas a smaller one frequently contains a very definite central knot (pl. 4, F). Each of many of the neps found in slivers and rovings possesses one long out-stretched fiber (pl. 3, D) which gives the impression that during the drawing process a loose tangle has been knotted more tightly by the pulling of this particular fiber. In some instances this fiber can be entirely pulled out and the tangle thus loosened; in other cases the pulling upon the fiber results in a tightening of the knot; and in still other cases it is only a matter of coincidence that the fiber is oriented in this way, and pulling upon it has no effect upon the general tangle.

Consideration was given to the possibility that abnormalities on fibers might play an important part in nep formation (pl. 3, C, E, and F). These peculiar growths may occur on any fiber but seem to be especially abundant on the fuzz fibers. They appear to be excellent centers around which other fibers might become entangled and thus form neps. In only a few instances, however, has it been demonstrated that an abnormality was actually the point at which the fibers had been caught.

SEED-COAT FRAGMENTS

In a macroscopic examination of any cotton sample (whether of ginned lint, sliver, roving, or yarn) many of the structures which at first glance are considered to be tangled knots of fibers (pl. 1, A–F) upon closer examination are found to be small fragments of seed coat (pl. 4, G and H). These fragments were found to be of two kinds: Fragments of mature seeds (pl. 4, H) and fragments of motes that have been crushed during ginning (pl. 4, G).

The greater part of the mature seed-coat fragments in the lints examined are produced as a result of the pulling away of the chalazal

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[8] That the number of neps per gram is less in the yarn than in the fine frame roving is probably explained by the fact that all the neps present in the yarn were not seen (p. 5).

end (blunt end) of the seed coat during the ginning process (pl. 2, F). This area of the seed coat seems to be brittle. It is frequently pulled off and the resulting fragments, with the long fibers still attached, appear in the ginned lint (pl. 2, G). The complete removal of all of the long fibers from the chalazal region is occasionally accompanied by a rupturing of the seed coat and small particles possessing only fuzz fibers may thus be detached from the seed. It is possible that the rubbing which the seeds undergo in the seed roll may loosen from chipped seeds other small particles, some of which become separated from the seed roll and are worked into the lint.

Some of the larger fragments found in ginned lint may be portions of seeds cut or broken by the teeth of the gin saw. In the lints examined the number of fragments produced in this way cannot have been very large for an examination of ginned seeds showed that the number of seeds chipped at the chalazal end far exceeded the number actually cut by the teeth of the gin saw; for example, 775 out of 24,000 seeds examined from one series of ginning tests were chipped at the chalazal end and only 12 were cut by the gin saw; in a second series of tests, 827 out of 15,000 seeds examined, showed chalazal chipping and 64 were cut by the gin saw.

The small tip at the micropylar end of the seed also may break off during the ginning of the cotton. These fragments were found to be of frequent occurrence in the ginned lints studied but, because they usually possess very few fibers, they are not readily held by the lint and consequently were rarely found in the products of any of the manufacturing processes.

The second group of seed-coat fragments are particles from structures generally termed "motes." No exact definition exists for the word "mote" as it is used in the cotton industry. Rea (*22, p. 1064*) states that "mature locks of upland cotton often contain aborted ovules which commercial ginners commonly call motes." Palmer (*20, p. 10*), when discussing quality in ginned lint defines motes as "immature and unfertilized seeds or the ends of seeds that are pulled off in ginning." Ginners usually consider as motes all the trash that drops into the mote box or conveyor during ginning, and this material may include immature seeds and portions of broken mature seeds as well as bits of foreign matter. Light specks on dyed cloth are occasionally called motes (*11*). In the following discussion a mote is considered to be an aborted ovule or an immature seed (pl. 2, A, B, and C).

Although aborted ovules of very small size occur in seed cotton, this discussion is concerned chiefly with motes of larger size (pl. 2, B and C). Some of these may be nearly as large as matured seeds and possess long thin-walled fibers.

During ginning many of the motes that are present in the seed cotton are separated from the lint or are "moted out" and collect in the mote box; others pass into the lint uninjured; many of the larger ones are ginned, the weak fiber being an undesirable addition to the lint; and still others are crushed. The crushed motes may remain in the lint as more or less definite lumps, or their fragments may be scattered throughout the lint.

Small mote fragments usually can be distinguished from small mature seed-coat fragments by the fact that the mote testa is generally light in color and its fibers are thin-walled (pl. 4, G and H). In a study of motes themselves, however, it was found that in some cases the fibers are short and thick-walled and the shrivelled testa is dark in color. Fragments from such motes cannot be distinguished from mature seed-coat fragments possessing only the short fuzz fibers.

The seed-coat fragments found in ginned lint varied in size from microscopic bits to the large chalazal fragments of mature seeds or the equally large or larger portions of crushed motes. The fragments occurring in slivers, roving, and yarns are usually of no greater size than those shown in plate 1, B, D, and E (*a–d*). It is realized, of course, that the term nep, even in its broadest sense, cannot be applied satisfactorily to the large fragments. Nevertheless, in a study of ginned lint samples, it has not seemed always advisable to consider the larger fragments separately from the smaller ones. Therefore, in calculating the total number of seed-coat fragments per gram in ginned lints, all fragments are counted except those that are considerably larger than the average-sized chalazal fragment.

Seed-coat fragments, whether large or small, cause trouble for the manufacturer. The small fragments, frequently termed "bearded motes" cling to the lint tenaciously (*12*) and, according to Midgley (*18, p. 20*), "there is no way of satisfactorily removing them, apart perhaps from combing." Yarn that possesses these fragments in large numbers has a rough and dirty appearance. Some of the large seed-coat particles as well as the crushed motes occurring in the lint, probably are entirely removed during carding. It is possible that others are further broken up during this and the following manufacturing processes, thus increasing the actual number of seed-coat fragments present. That such an increase in number does occur during the manufacturing of yarn is brought out in table 3, in which it is seen that in every instance the yarn possesses more seed-coat fragments per gram than did the raw cotton from which it was spun.

TABLE 3.—*Increase in number of seed-coat fragments during the process of converting raw cotton into yarn*

Cotton	Seed-coat fragments per gram in—			Cotton	Seed-coat fragments per gram in—		
	Raw cotton	Card sliver	Yarn		Raw cotton	Card sliver	Yarn
	Number	*Number*	*Number*		*Number*	*Number*	*Number*
A	2.24	8.90	6.85	D	33.37	59.36	54.72
B	7.23	7.71	18.45	E	28.1	20.74	64.69
C	11.15	12.92	41.01	F	13.84	21.11	25.36

These observations serve to emphasize the importance of seed-coat fragments as one of the factors to be considered in estimating the quality of ginned cotton.

Studies now being conducted indicate that the number of mature seed-coat fragments occurring in ginned lint varies with different methods of conditioning and ginning as well as with different types of cotton. Moreover, there is some evidence that methods of conditioning and ginning may influence the number of motes that become crushed.

FRAGMENTS OF COMPRESSED FIBER MASSES AND FRAGMENTS FROM DRIED DISEASED AREAS

Portions of compressed fiber masses or fragments from dried diseased areas occurring on seeds may be present in the ginned lint in various sizes and numbers and are important from the standpoint of actual waste. Many of these fragments are very indefinite; it is therefore difficult, if not impossible, to make even a fairly accurate estimation of the number of such fragments present in a ginned lint sample. Moreover, many are very large.

A consideration of these fragments and the conditions giving rise to them is warranted, however, by the fact that small definite fragments from such masses occur in slivers, rovings, and yarns and occasionally may form as high as 5.8 percent of the total nep content of a yarn (table 1).

On the surface of many locks there are glistening areas of various sizes which have the appearance of shiny paper (pl. 2, D). Such areas may be found on mature seeds but are of more frequent occurrence on the large motes (pl. 2, C). Microscopic examination shows these areas to be composed of very thin-walled fibers compressed into thin sheets. Some of these masses are capable of being separated into their individual fibers; other masses have been transferred into rather brittle sheets in which the individual fibers have practically lost their identity. These brittle compressed-fiber masses may be broken during ginning into flakes of various sizes. Carding may rid the lint of most of these fragments but small flakes may be found in slivers, rovings, and yarns (pl. 4, E). These fragments were not found to form more than 4.34 percent of the total nep content (table 1) of any of the yarns studied, nor were they more numerous than 8.83 per gram of yarn.

Other locks are found on which occur diseased areas (pl. 2, E) resulting from insect injury, fungus infection, or both. The masses of diseased areas usually are separated from the lint during ginning, but occasionally the diseased seeds are ginned, the matted mass of fibers being torn into fragments of various sizes, some of which are very small (pl. 3, A). Bits of such matter may remain in the card sliver and even persist into the yarn; however, in the yarns examined, these fragments were not found to form more than 1.92 percent of the total nep content (table 1), nor were they more numerous than 3.08 per gram of yarn.

SUMMARY AND CONCLUSIONS

A workable system for the general classification of neps and similar imperfections occurring in ginned lints, slivers, rovings, and yarns is presented.

Most of the small imperfections found in the materials studied may be divided into two groups: Neps proper and fragments of seed coat.

Neps proper consist only of tangled fibers; 15 kinds of neps are differentiated according to the type or types of fibers entering into the composition of individual neps, the fibers being classified for the purpose of this study, as: (1) Thick-walled fibers, (2) medium-walled fibers, (3) thin-walled fibers, and (4) fuzz fibers.

Seed-coat fragments are of two kinds: Fragments of mature seeds resulting, in the main, from the pulling off of the chalazal end of the seed during ginning and fragments of motes crushed during ginning.

In addition there occur in small numbers: (1) Knots formed by fibers becoming entangled around small seed-coat fragments or bits of foreign matter, (2) fragments from compressed brittle fiber masses, and (3) fragments from dried diseased areas on locks.

This classification includes all small imperfections occurring in ginned lints, slivers, rovings, and yarns that originated from the seed cotton itself. No foreign matter is included except small particles around which fibers may have become knotted.

This investigation has led to several conclusions regarding nep formations in the particular cottons studied. How far these conclusions are true of cottons other than those included in this study is a problem for future consideration. The points brought out are as follows:

In most of the samples studied, thin-walled fibers entered into the greatest number of neps and thick-walled fibers into the least, neps that possessed medium-walled or fuzz fibers being intermediate in number. This observation, together with the fact that thin-walled fibers knot up alone much more readily than do medium-walled, thick-walled, or fuzz fibers, justifies the conclusion that in these cottons the thin-walled fiber is the most important type of fiber from the standpoint of nep formation.

There is evidence that the proportions in which the various fiber types occur on the seed, as well as other properties of the seed cotton, are factors that influence the number of neps developed during the ginning and spinning processes.

The number of neps appears to be increased during the manufacturing processes.

No essential differences were found between the composition of neps occurring in ginned cotton and those found in the products of the manufacturing processes.

The fibers in neps do not appear to be entangled in any definite manner. Large neps usually are an irregular tangled mass of fibers, whereas small neps frequently possess a definite central knot.

Abnormalities on fibers were not found to play an important part in nep formation.

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