ADEQUACY OF LABELING OF CERTAIN TEXTILE FABRICS WITH REGARD TO FIBER CONTENT [1]

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INTRODUCTION

It has become difficult to ascertain the fiber content of fabrics by their appearance and handle or by chemical and burning tests. Formerly, it was a simple matter to determine whether a fabric was silk, cotton, linen, or rayon. New finishes, however, have been devised to give the synthetic fabrics the appearance of wool, linen, or silk. Furthermore, there has been an increasingly large production of fabrics composed of two or more kinds of fibers. Experienced textile workers have frequently been unable to determine fiber content without using exacting methods of identification. Because the kinds of fibers used cannot be determined without reliable laboratory techniques, fabrics on the market should have labels stating accurately the fiber content. Such accurate statements of the fiber content would enable the consumer to exercise proper care in dry cleaning and laundering and would be of particular value to those who are allergic to certain textiles (*18*).[3]

This paper reports an investigation to ascertain to what extent authentic information was available to the purchaser concerning the fiber content of fabrics on the open market.

RULINGS ON FIBER CONTENT OF TEXTILES

Some attempts have been made to state the fiber content of textiles. The Federal Trade Commission adopted a ruling on May 26, 1930, that "the word 'wool' shall not be used in any way in labeling, advertising, merchandising, or selling of knit underwear unless the percentage by weight of wool contained in the garment be stated."[4] A commercial standard for wool and part-wool blankets (*23*) became effective April 1, 1933, which provided for the labeling of part-wool blankets with the guaranteed minimum wool content, and one for wool and part-wool fabrics (*24*) became effective January 1, 1938. On October 27, 1937, the Federal Trade Commission issued its ruling of fair trade practices for the rayon industry (*20*). The new rules define rayon as "the generic term for manufactured textile fiber or yarn produced chemically from cellulose or with a cellulose base." In mixed fabrics containing rayon, it is required that the kinds of fibers and the percentages of each by weight be given on the labels. The ruling concerning rayon has met with some opposition. New rules were pro-

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(895)

mulgated November 4, 1938, for the silk industry. These rules recommend that silk fabrics be labeled as such and that mixed fabrics containing silk have the percentages of the different fibers given (*21*). The Federal Trade Commission also proposed trade practice rules for the wool industry in November 1938 (*22*).

MATERIALS

The fabrics tested in this investigation were purchased in 18 different stores in 7 towns and cities of the Midwest. At the time of purchase any information on the labels with regard to fiber content was noted. When the fiber content was not stated on the label, as much information as possible was obtained from the salesman. Of the 268 fabrics purchased, 133 contained only one kind of fiber, and 135 were of mixed fiber content. It was soon learned that the information concerning mixed fabrics and synthentic fabrics was least reliable, and an effort was made to select as wide a variety of these as possible. Few all-cotton and all-linen fabrics which were thought to be correctly labeled were purchased.

METHODS OF IDENTIFICATION AND ANALYSIS

MICROSCOPIC IDENTIFICATION OF FIBERS

Before any quantitative determinations of the fabrics were made, the kinds of fibers were determined. The microscope was generally used for identification because microdeterminations required less time and proved more conclusive than chemical tests. A comparison of longitudinal and cross-sectional mounts of the unknown fiber with a series of known specimens was employed. A permanent set of slides of authentic fibers most likely to occur in textiles was prepared. Plates 1 and 2 show photomicrographs of three rayons.

Many fibers could be identified by longitudinal mounts, but for the identification of silk and the various rayons cross sections were necessary. Cross-sectional mounts, accordingly, were made by the Viviani cork method (*5, 14, 15, 25*).

Surface details of the wool fibers were studied by means of casts (*3, 8, 9, 15*).

Polarized light proved to be valuable in the identification of highly birefringent vegetable and rayon fibers. Difficulty in differentiating between linen and mercerized cotton fibers was overcome by examination between crossed Nicol prisms. Polarized light brought the nodes of linen into greater prominence.

In some of the identification work, confirmatory tests were made by using certain dyes. Millon's reagent was used in distinguishing animal from vegetable fibers, and Neocarmin B and Meocarmin W were used in identifying the rayons.

QUANTITATIVE MECHANICAL ANALYSIS OF MIXED FABRICS

When a fabric was composed of one kind of fiber, only the fiber identification was needed. When a fabric contained two or more kinds of fibers, a quantitative analysis was necessary. This analysis was made as follows:

Two samples of each fabric, weighing approximately 5 g were taken. The sizing, finishing, and other nonfibrous materials were
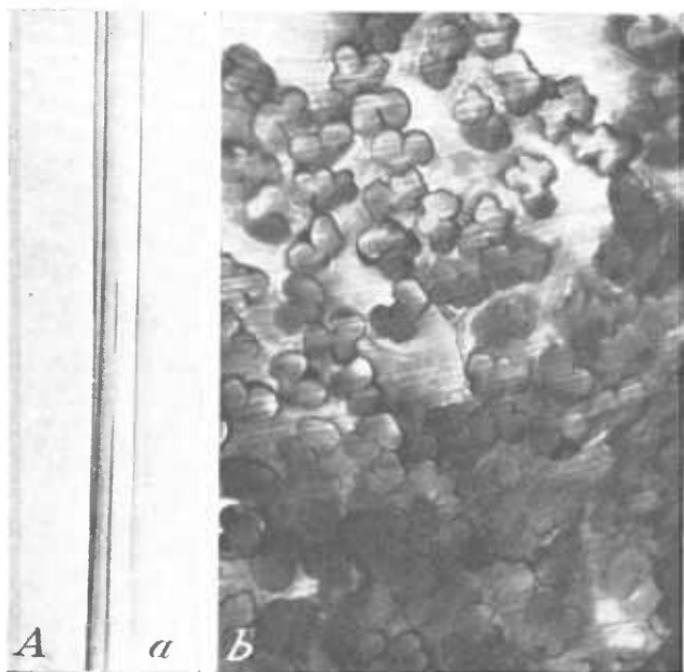
A, Cellulose acetate rayon fibers: *a*, Longitudinal view, Canada balsam mount, $\times$ 380; *b*, cross section, air mount, $\times$ 350. *B*, Cuprammonium rayon fibers: *a*, Longitudinal view; *b*, cross section.   Glycerin mounts, $\times$ 380.
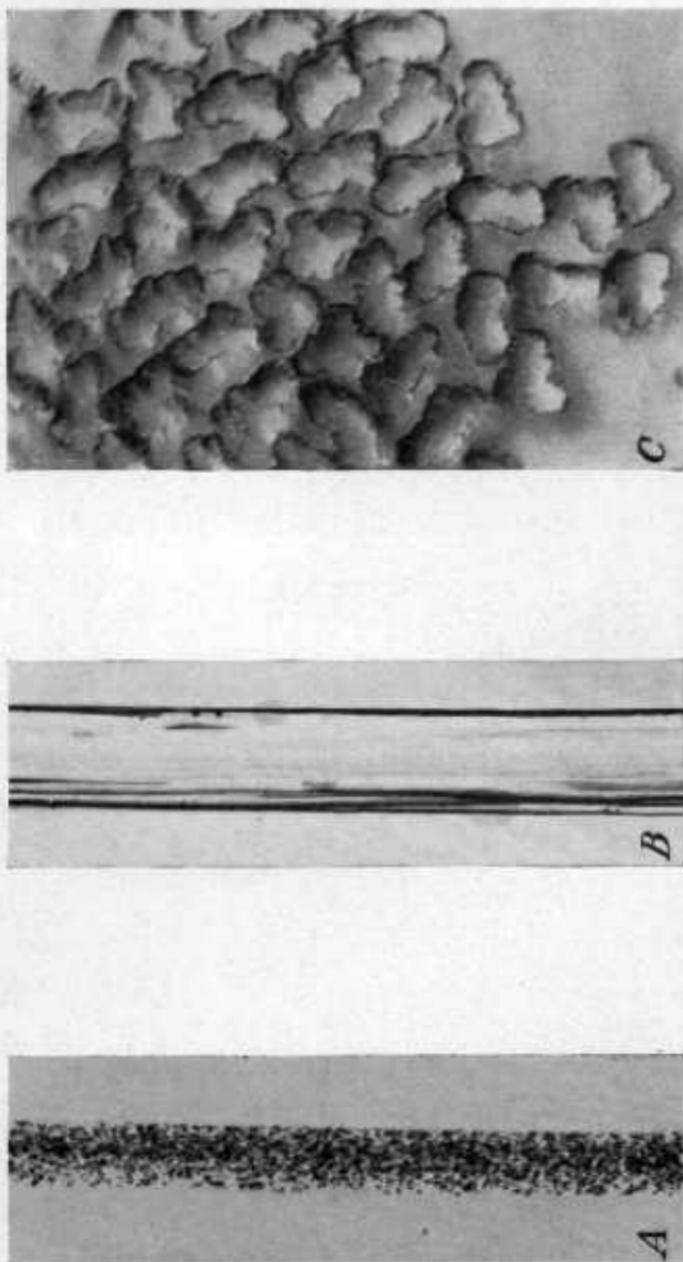
Viscose rayon fibers: *A*, Longitudinal view, delustered, Canada balsam mount, × 350; *B*, longitudinal view, lustrous, glycerin mount, × 380; *C*, cross section, lustrous, glycerin mount, × 380.

removed by extraction with carbon tetrachloride and a 3- to 5-percent aqueous solution of a starch-hydrolyzing enzyme. These operations were carried out according to the directions of the American Society for Testing Materials (*1*). The dried weight of the samples was found, and a suitable quantitative analysis was used in determining the fiber content.

There are three fundamental ways of determining the fiber content quantitatively—mechanically, microscopically, and chemically. The mechanical method when applicable is the most accurate. When the fibers are mixed before the yarn is spun, mechanical separation is not feasible. Ply yarns having one ply of one kind of fiber and one of another are often used in weaving fabrics. The mechanical separation of the plies is frequently a better method to use than a tedious and less accurate chemical analysis. Fabrics woven from two different kinds of yarn are easily analyzed mechanically. Many fabrics have the warp yarns of one fiber and the filling of another.

QUANTITATIVE CHEMICAL ANALYSIS OF MIXED FABRICS

Several chemical analyses were checked; samples of known fiber were used in order to determine which methods were most applicable. If cellulose acetate rayon was present in a mixed fabric, it was removed first by dissolution in acetone. Acetone readily dissolved acetate rayon with an error of less than 1 percent whenever cotton, silk, wool, or regenerated cellulose was present. The method followed in the use of acetone was that given in the Standards on Textile Materials (*1*). Two samples were run simultaneously and agitated at room temperature in the Launder-Ometer for 15 minutes in about 50 times their weight in acetone.

Silk, if present, was removed next. The method of dissolving silk in Lowe's reagent [5] at room temperature for 20 to 30 minutes was found to be the quickest and most accurate of those tried. The residual samples always gained weight because of the deposit of a gelatinous copper compound which was removed by rinsing the samples in a 1- to 2-percent hydrochloric acid solution before washing with distilled water.

There are several methods (*1, 2, 6, 7, 10, 12, 13, 19, 24*) of determining the wool content in mixtures of wool, cotton, and rayon. Cotton and regenerated cellulose may be separated from wool by carbonization with aluminum chloride. In the work reported herein, the sample was immersed for 10 minutes in a boiling solution of aluminum chloride containing 9 g of hydrated chloride per 100 ml of water. After the sample was heated in an oven at 105° to 110° C. for 2 hours, it was rubbed against a 100-mesh screen with sufficient pressure to powder the carbonized cellulose and pass it through the screen. The material was passed through the screen again to recover any wool fibers that had passed through the first time. The wool was agitated with about 100 ml of a 10-percent solution of hydrochloric acid, then washed with distilled water until free from chlorides and dried. The error involved in this method was less than 1 percent.

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[5] The reagent is made of 16 g of copper sulphate in 150 ml of water, with the addition of 10 g of glycerol. A concentrated solution of sodium hydroxide is added until the precipitate of copper hydrate, which at first forms, dissolves.

When wool comprised the greater portion in a mixture of wool and cotton or wool and regenerated cellulose rayon, it was removed with a solution of potassium hydroxide as shown by Mease and Jessup (*12*). The samples were boiled for 10 minutes in a 5-percent aqueous solution of potassium hydroxide. A reflux condenser was used to prevent concentration of the alkali because of evaporation. The samples were rinsed in a 5-percent aqueous solution of acetic acid, and then in distilled water until free from acetic acid. Potassium hydroxide dissolved wool readily with little effect on cotton. Regenerated cellulose was affected somewhat by this method, the error being approximately 3 percent; but with cotton the error was less than 1 percent.

Cotton was separated from regenerated cellulose by an aqueous solution of calcium thiocyanate as described by the American Society for Testing Materials (*1*). The samples were agitated for 1 hour at 70° C. in 200 ml of calcium thiocyanate, of specific gravity 1.35 to 1.36, slightly acidulated with acetic acid. The error was approximately 2 percent.

Table 1 shows the effects of the various reagents upon the textile fibers. Correction factors were not used except when potassium hydroxide was used to dissolve wool mixed with regenerated cellulose rayon. The weight of regenerated cellulose was found by multiplying the dry weight obtained in the analysis by 1.03.

TABLE 1.—*The effect of various solvents on different textile fibers*

Fiber	Acetone	Lowe's reagent	Aluminum chloride	Potassium hydroxide	Calcium thiocyanate
Cellulose acetate.	All dissolved____				
Silk_____	Less than 1 percent dissolved.	All dissolved____			
Cotton_____	____do_____	Less than 1 percent dissolved.	All carbonized__	Less than 1 percent dissolved.	Approximately 2 percent dissolved.
Regenerated cellulose.	____do_____	____do_____	____do_____	Approximately 3 percent dissolved.	All dissolved.
Wool_____	____do_____	____do_____	Less than 1 percent carbonized.	All dissolved____	Approximately 2 percent dissolved.

QUANTITATIVE MICROSCOPICAL ANALYSIS OF MIXED FABRICS

Although there is an increasing realization that the volume of each fiber present in a mixed fabric is as important as the weight of each fiber present, comparatively little work has been done on quantitative microscopical analysis. Heretofore, most quantitative analyses of fibers have been based on percentage weight as determined by chemical analysis. The microscope lends itself to volumetric as well as gravimetric determinations. Quantitative microscopical analysis of textile fabrics is often the most desirable, and sometimes the only, method which can be used. Fabrics made of yarns which are blends of fibers lend themselves to microscopical analysis. If one kind of fiber constitutes a very small percentage, it is often better to resort to microscopical analysis rather than to a chemical analysis in which the loss of the fiber of small percentage may amount to a great deal.

Blends of viscose rayon and linen, or of viscose rayon and cotton may be analyzed by dissolving the rayon in calcium thiocyanate. After the solution is used, it must be diluted until the rayon is precipitated, and then evaporated before it is ready to be used again. The microscopical analysis is often to be preferred to the chemical analysis.

Blends of different kinds of wools cannot be separated by chemical analysis, and microscopical methods must be used. Skinkle (*16, 17*) and von Bergen (*26*) made analyses of wool and mohair and other animal fibers, identifying the kind of fiber by measuring scale sizes and diameters and counting the number of each kind in a cross section of yarn.

Heermann and Herzog (*4*) showed that the percentage of each kind of fiber in a mixture could be found by the equation

$$\text{Percentage of fiber } A = \frac{100 n_a g_a}{n_a g_a + n_b g_b}$$

where n is the number of fibers and g is the weight of each fiber per unit of length. Skinkle (*17*) in his work on animal fibers, which are nearly round in cross section and of approximately the same density, expressed the percentage by the equation

$$\text{Percentage of fiber } A = \frac{100 n_a d_a^2}{n_a d_a^2 + n_b d_b^2}$$

where d is the average diameter of the fibers and n is the number of fibers.

This equation can be modified to calculate the percentage of fibers which are of irregular cross section without the determination of weight of the fibers per unit length as done by Heermann and Herzog.

Two methods were used by the present writers for counting the number of each kind of fiber. For blends of linen and viscose rayon, of cotton and viscose rayon, or of cotton and linen, the number of each kind of fiber was counted by cutting as small a length of the yarn as possible, less than one-sixteenth of an inch, with small shears. The small lengths were mounted in glycerin and teased out as uniformly as possible on the slide. A magnification of 100 or less was used with a 16-mm objective, and the total number of fibers of each on the entire slide was counted by moving the slide with a mechanical stage which had two graduated scales at right angles. The distinguishing of linen from cotton could often be facilitated by placing the slide between crossed Nicol prisms. Ten slides or more were prepared from yarns taken from various parts of the fabric, and the average of the counts on the 10 slides was taken as the number of fibers of each kind in the yarn.

The above method was used for blends in which one kind of fiber made up a very small percentage of the yarn and for fibers of which it is difficult to make cross sections.

For blends of different kinds of wools, of rayon and wool, and of wool and cotton, the counting of the fibers was done by making cross

sections by the Viviani cork method. A magnification of about 300 with a 4-mm objective was used. A field was chosen at random, and the number of sections of each kind of fiber was counted. Ten to twenty different fields of the same size were counted, and the average of each kind was taken as the number of fibers. Plate 3 shows photomicrographs of cross sections of yarns of various kinds of mixed fabrics.

The relative areas of the fibers were found by drawing 10 or more cross sections with the camera lucida as pointed out by Preston (*14*). The cross sections were cut out and weighed on an analytical balance, and the average weight of the paper drawings of each kind of fiber was calculated and taken as proportional to the size of the fiber. The percentage by volume of each kind of fiber in a blend can be expressed by the equation

$$\text{Percentage of fiber } A = \frac{100 n_a w_a}{n_a w_a + n_b w_b}.$$

The percentage by weight of each can be expressed by the equation

$$\text{Percentage of fiber } A = \frac{100 n_a w_a g_a}{n_a w_a g_a + n_b w_b g_b}.$$

In the equations n is the number of fibers, w is the average weight of camera-lucida drawings of the cross sections, and g is the specific gravity of the fiber. The values of the specific gravities were taken from Heermann and Herzog (*4*) and the International Critical Tables (*11*).

RESULTS AND DISCUSSION

Table 2 gives the results of the examination of the 133 fabrics of one kind of fiber. In each case the information on the label and that given by the clerk were compared with determinations made in the laboratory. Ordinarily the salesmen gave no further information if the fiber content of the textile was stated on the label. An acetate rayon fabric was considered accurately labeled if given as celanese rayon, acetate rayon, or acetate, and only partially accurate if given as rayon or celanese. The information with regard to fiber content of a fabric of cuprammonium rayon was considered accurate if given as cuprammonium rayon, cuprammonium, or Bemberg rayon, and partially accurate if given as Bemberg or rayon. In the case of viscose rayon, viscose rayon or viscose was counted as accurate, and rayon as partially accurate.

A mixed fabric was considered to be accurately labeled if the kinds of fibers that it contained were given. Viscose rayon had to be given as viscose rayon or viscose; cuprammonium rayon as cuprammonium rayon, cuprammonium, or Bemberg rayon; and acetate rayon as acetate rayon, acetate, or celanese rayon. If the percentage of fiber content was stated, the information was considered accurate if the percentage was correct within 10 percent. It was considered partially accurate if one kind of fiber contained in the fabric was given, and the others were not. Table 2 also gives the results of the examination of these fabrics.
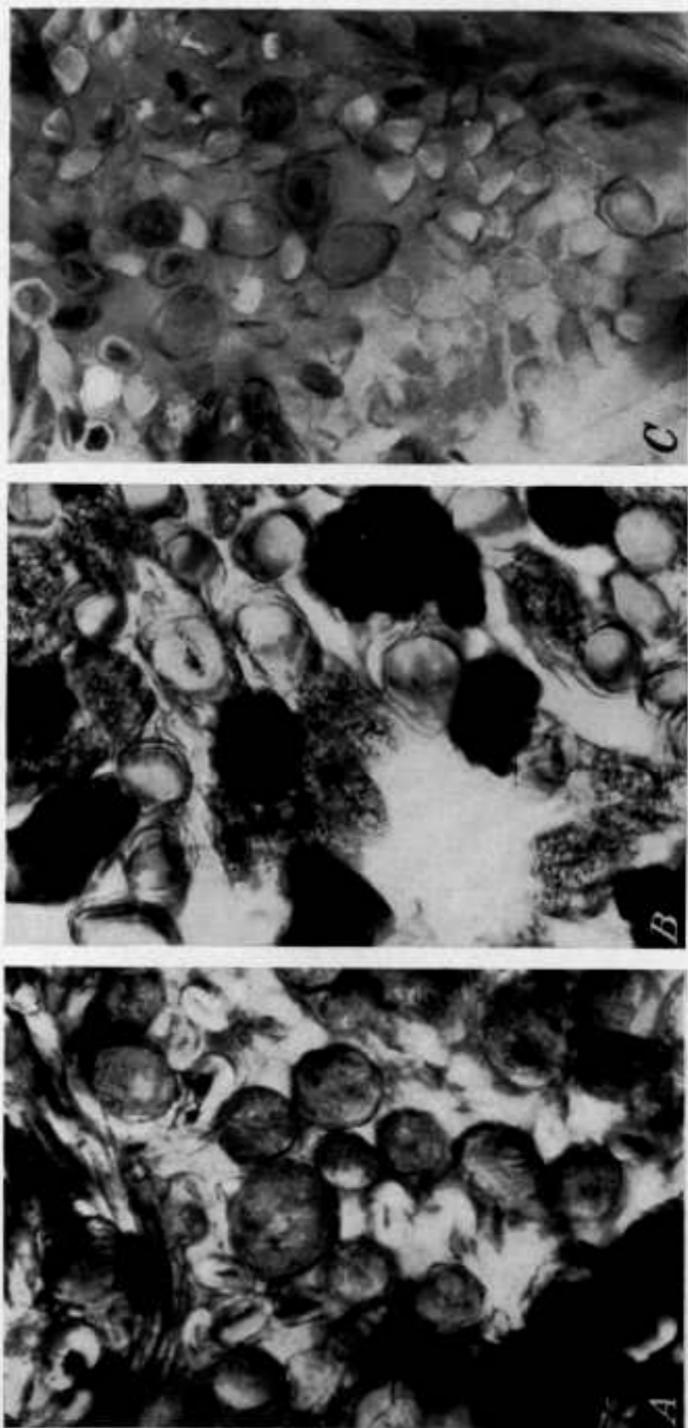
A, Blend of wool and cotton, cross section, glycerin mount, × 380; *B*, blend of wool, delustered viscose, and dyed viscose, cross section, glycerin mount, × 380; blend of wool, silk, and rabbit fur, cross section, glycerin mount, × 380.

TABLE 2.—*Adequacy of information secured from labels or salesmen concerning fabrics composed of one kind of fiber or of mixed fibers*

FABRICS OF ONE KIND OF FIBER

Fabrics analyzed		Fabrics that were—				Fabrics regarding which salesmen gave —			
Kind	Number	Labeled	Labeled accurately	Labeled partly accurately	Labeled inaccurately	Information	Accurate information	Partly accurate information	Inaccurate information
		Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Cotton	4	2	2	0	0	2	1	1	0
Linen	3	3	3	0	0	0	0	0	0
Silk	26	11	11	0	0	16	13	2	1
Wool	14	5	5	0	0	9	8	0	1
Acetate rayon	16	7	1	5	1	9	2	7	0
Cuprammonium rayon	13	5	1	4	0	8	1	7	0
Viscose rayon	57	24	0	23	1	35	0	31	4
Total	133	57	23	32	2	79	25	48	6
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Proportion		100	40.4	56.1	3.5	100	31.6	60.8	7.6

FABRICS OF TWO OR MORE KINDS OF FIBERS

Kind	Number	Labeled	Labeled accurately	Labeled partly accurately	Labeled inaccurately	Information	Accurate information	Partly accurate information	Inaccurate information
		Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Cotton and wool	11	2	0	2	0	11	4	5	2
Cotton and viscose	15	3	0	3	0	13	0	11	2
Cotton and linen	6	5	0	5	0	2	0	2	0
Wool and rabbit fur	3	0	0	0	0	3	1	2	0
Wool and viscose	21	4	0	4	0	19	0	18	1
Wool and silk	5	2	0	2	0	5	1	4	0
Silk and viscose	7	2	0	2	0	5	0	5	0
Acetate and viscose	43	12	0	12	0	31	0	30	1
Various fabrics composed of 2 kinds of fibers	6	1	0	1	0	5	2	3	0
Various fabrics composed of 3 kinds of fibers	18	3	0	3	0	16	1	14	1
Total	135	34	0	34	0	110	9	94	7
		Percent		*Percent*		*Percent*	*Percent*	*Percent*	*Percent*
Proportion		100		100		100	8.2	85.4	6.4

SUMMARY

Table 2 shows that of the fabrics analyzed those made of cotton, linen, silk, and wool were commonly accurately labeled and that salesmen, in the main, gave accurate information with regard to these fabrics bearing no label with regard to fiber content. Of all the fabrics made of one kind of fiber, the information concerning the three types of rayon was found to be least accurate. These fabrics were often represented as "rayon," but they were usually not designated as acetate, viscose, or cuprammonium rayon. The word "celanese" was often used instead of acetate; Bemberg and Bemberg rayon were always used instead of cuprammonium rayon; and rayon was used instead of viscose rayon. Of the 133 fabrics of 1 kind of fiber analyzed, 57 were labeled. Of these, 40.4 percent were accurate; of the 79 for which salesmen gave information, 31.6 percent were accurate. Thus the information on the label was found to be more accurate than that given by the salesmen.

Of the 135 mixed fabrics, 117 were made of 2 kinds of fibers, and 18 were of 3 kinds. Many of these had warp yarns of one kind and filling of another. Some were made of yarns which were blends, and

others of ply yarns composed of plies of different kinds of fibers. Cellulose acetate rayon and viscose rayon were most frequently found in combination. Only one fabric of each of the following combinations was found: Viscose and linen, linen and wool, acetate and cuprammonium rayons, acetate rayon and silk, wool and cuprammonium rayon, and wool and mohair.

Little information was obtained concerning the percentage of fiber content, either from the labels or from the salesmen. Only one fabric bore a label stating the percentage of fiber present. The label stated that the fabric contained 25 percent of wool, but analysis showed only 15 percent to be present. The clerks gave percentages for fiber content for 12 fabrics, of which 1 was accurate, 10 partially accurate, and 1 wrong.

Of the 135 mixed fabrics examined, only 34 were labeled; and all of these were only partially accurate. The clerks gave information concerning 110, of which 8.2 percent were accurate, 85.4 percent partially accurate, and 6.4 percent wrong.

It is apparent that more of the fabrics of one fiber are labeled, and more of the information accurate, than of mixed fabrics, but in case of the labeled fabrics of one kind of fiber the accuracy was only 40.4 percent. The accuracy of the information, from labels and from salesmen, for both groups of fabrics was inadequate.

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