Wool, Woolens, and Worsteds Through the Microscope*

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Every little while there crops up a proposition leading to the manufacture of an artificial wool. Often these attempts are wrongly named, since the effort is confined to making a fiber which will blend well with wool, or to using some natural fiber of vegetable origin which has been processed in some way to make it suitable for blending. It is borne in on the writer, on each of these occasions, that the backers of such schemes can seldom have really examined a wool fiber under the microscope, nor can they have subjected the fiber to physical tests such as those for elasticity, strength, etc. If they had, most of the plans would have died at birth.

The peculiar properties of the wool fiber which have rendered it a textile raw material of major importance since the earliest times, are even yet but little understood. Recent investigations by the British Textile Institute (1) throw some light on the question, and indicate that, in many respects, a model made up of a cylinder containing a piston which works in a somewhat viscous fluid and is aided and resisted by external and internal springs, duplicates many of the properties of stretch, and stretch recovery or elasticity, found in the natural fiber. If the structure called for must be so complicated as this would indicate, as the micro-analysis of wool substantiates, there would appear to be little hope for a simple solution of the problem of a cheap synthetic substitute, or of a product of vegetable origin to duplicate it.

Effort might much better be directed to a more thorough understanding of the peculiar properties of the different wools, and to a surer knowledge of the effects of changes in physical and chemical structure on the manufacturing processes. Certain of the sheep raisers, notably in New Zealand, have combined to measure the physical properties of the wools which they grow. Their idea is simply to find out how to produce any or all of the required characteristics such as crimps per inch, scales per inch, type of scale, diameter of fiber, shape of the fiber cross section, etc. That their effort has not been entirely vain in this regard is evidenced by the fact that already considerable progress has been made in this line, and the buyer can now specify what he wants and be reasonably sure of getting it. The unfortunate thing, however, is that very few indeed of the manufacturers know what they want. They do not know, for example, how the number of crimps per inch affects their particular product. True, they may guess at, or worse, take somebody else's say-so, but *they do not know.*

Thus, all the praiseworthy use of testing equipment, microscopic or otherwise, by the wool growers will avail but little so long as the manufacturers fail to make adequate use of the same equipment as it bears upon their processes and finished goods. If the microscope can produce the information for the raisers of the fiber, it can do the same for the spinner, weaver, and converter of it. Too often we hear the complaint that the buyer is purchasing dollars and cents—that is, he is driving what he fondly supposes is a good bargain, rather than obtaining the wool best suited for his needs. A contractor would hardly dare to attempt the construction of a skyscraper or a bridge without first rigidly specifying the physical and chemical properties of the steel, cement, etc., which entered into the work. Nor is he content to simply specify, he will test the materials to see that they conform to the specifications.

More and more is this same attitude being taken in textiles. For a number of years, cotton textiles which were used as mechanical fabrics, tires, belts, airplane wing and balloon materials, and so on through the long list, have had to meet specifications, and through this fact, the science of textile testing has largely been developed. In its later stages, the use of the microscope has come more and more to the fore. There is no reason why microscopic equipment should not be applied to textiles which have hitherto been and will continue to be largely of a decorative nature. Thus woolens and worsteds may be advantageously studied microscopically.

Structure of Wool Fiber

The microscope will afford an opportunity for the minute investigation of the internal structure of the wool fiber, which, as we have said, is fundamental. It will reveal that the fiber is composed of an outer sheath or cuticle which carries the scales. Inside this cuticle, which is elastic, we find a layer of spindle-shaped cells packed closely together, and affording a medium more or less resistant to stretch, and tenacious of this elongation when once obtained. Inside the cortical layer is the medulla, which may contain air cells—as in kemps—or may serve as a retainer for pigment, in a more or less granular form. It may be continuous throughout the length of the fiber; it may be intermittent; or it may be apparently missing altogether. In certain hairs its

*Photomicrographs by the author.

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form is quite characteristic and aids greatly in identification of the material in which it appears.

Fig. 1. Cross-section of Imitation Wool Fibers

The scales will be seen to differ in shape and placement in wools of various types. In mohair, they are almost invisible, and have serrated edges, the scale extending almost completely around the fiber. In the coarser wools, the scales are smaller, have more projecting tips, and several scales are necessary to span the fiber circumference. The cuticle seems to be porous, and no doubt, much of the moisture absorbed by the wool from the atmosphere passes mechanically through these pores into the internal structure. Just what the mechanism of this action is nobody knows, but physical and microscopical investigations will show it after intensive enough study.

ever, to make the correlation at least tentatively, and recent research seems to show that the shape of the cross section has a large bearing upon the quality of the resulting yarn. It has been stated (2) that the more nearly circular the cross section is, the higher the number to which the fiber may be spun, other things being equal. The measurement and the study of the relations mutually existant between these "other things" is still a problem for the microscopist, the physicist, and the manufacturer. Dr. Barker also states that it is claimed that, as a rule, a greasy fleece contains finer fibers than one deficient in this respect. As an example of the present disagreement of authorities, Spencer, Hardy, and Brandon (3) state that after an exhaustive study of nearly 1,000 fleeces, and a careful correlation of some nine different factors, there was, if anything, a very slight tendency for the fibers to become finer (of smaller diameter) as the weights of the unscoured and scoured fleeces decreased. Their figures showed no correlation which could be considered significant, between weight of grease and fineness, nor between this latter factor and length of staple. They did fine a positive correlation of significant degree between the body weight of the yearling sheep and the fineness of the fiber. Whatever the correctness or falsity of the conclusions drawn; and whatever the cause of the apparent discrepancy, supposing both series of tests to be correct; it remains a fact that none of the work could have been undertaken at all had it not been for the availability and use of microscopic equipment.

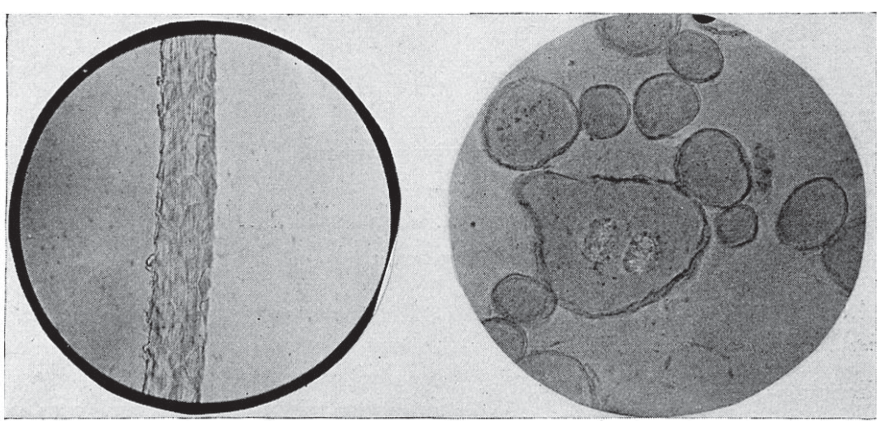

Fig. 2. Real Wool Fibers—Longitudinal and Cross-section

According to Dr. S. G. Barker (2) fineness of wool was determined as early as 1777, and since that time much work has been done to correlate this factor with the spinning qualities. Exact methods of test were lacking for the determination of the "spinning quality" and even yet science has a great contribution still to make in this direction. We are now better able, how-

Dr. Barker (2) has also investigated the nature of crimp in wool and from his microscopical study has been able to classify the various sorts of crimp which are to be found. Not content with this, however, he proceeded to attempt to reproduce the characteristic forms experimentally. By mechanically controlling the motion of an orifice, he was able to produce in the extruded filament issuing therefrom any and all of the forms noted. Whether there is actually such a motion of the follicle is a matter of speculation, and seemed somewhat doubtful. To investigate the matter further, Dr. Barker used a membrane and succeeded in obtaining crimped filaments by a process of osmosis. The province of both the physicist and the chemist, as well as the biologist and physiologist, are here invaded. Science as a whole must take a hand in the search for fundamental data, and here again the microscope takes its place in the forefront of the battle line.

Potsdamer and Schenker (4) have recently published the data accumulated as a result of a long series of careful microscopical tests of wool fiber leading to the possibility of better grading of wool. The success of their work is both encouraging and enlightening. It shows in good measure what the possibilities are that lie ahead. Similar studies have been undertaken by H. B. Gordon (5), Dr. McNicholas (6), J. A. F. Roberts (7), Brompton (8), Duerden (9), Winson (10), and a host of others as evidenced by the even yet fragmentary literature.

Felting properties of wools are still a moot subject for controversy wherever wool-men gather. Why do some fibers felt, and certain others fail to do so ? Many investigators have attempted to answer the question. Roberts Beaumont (11) outlines some of the conclusions, and points out that the phenomena cannot be related to a single cause, but that all of the factors noted by various workers have some bearing on the result. Probably fiber creep due to scale structure, fiber softening and consequent adherence of one fiber to another, and interlock of fibers because of crimp, together with the necessary conditions of heat, moisture, and pressure will be in large measure responsible. The quantitative effects of such other factors as orientation of the fibers, etc., must still be further investigated and related to the major items already listed. The use of the motion picture camera in conjunction with the microscope is likely to prove of immense importance in the study of the problem, for the recording of changes in controlled condition processing, carried out in suitable experimental apparatus.

The effects of chlorination and similar chemical treatments are being studied intensively abroad, notably by Herzog (12) much of whose work is reported in The Melliand. There is a fruitful field of study in the chemical reactions of wool, and one to occupy an indefinite length of time for many workers.

(*To be Continued*)

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