The Physical and Physico-chemical Problems relating to Textile Fibres.

IN the joint discussion held by the Faraday Society and the Textile Institute at the British Empire Exhibition, Wembley, on June 11, under the presidency of Sir Robert Robertson and Mr. Lester, a number of important developments of research on textile fibres was disclosed. The papers covered a wide field and dealt with the physical properties of cotton, wool, flax, and silk fibres. It is intended in this article to describe some of the points raised during the discussion rather than to refer in detail to the subject-matter of the papers, which is to be published later.

The introductory address was given by Dr. W. L. Balls, who proposed to divide physical research in textiles into two sections: (1) that relating to the physical unit in each raw material; and (2) that relating to the larger field concerned with the building up of the yarn and fabric. The appropriateness of this division is at once apparent; it separates, at least vaguely, the bio-physical problems from the mechanical ones, implying by the latter those problems concerned in the transformation of a mass of raw material into a useful yarn or fabric. In his conclusion Dr. Balls said: "The defects of yarn and fabrics which admittedly exist, together with other defects whose existence is not even recognised, were formerly due to faults in the machinery employed. Many of these have been eliminated in the course of time; and the physicist is now concerned rather with studying the causation of defects which are inherent in the properties of the raw material."

This warrants a note of criticism. The present writer pointed out that though the importance of physical tests on raw materials cannot perhaps be overstated, at any rate from the grower's point of view, yet at the same time it should be clearly understood that there are, on the industrial side, limitations to the profitableness of such work. I refer particularly to trade samples of raw material. It would no doubt be an easy though laborious matter to obtain valuable information concerning certain characteristics of the cotton fibres and their correlations, for example, provided one confines the effort to one or more special varieties. But it must be borne in mind that the practical spinner has no direct interest in special varieties; he buys and mixes his raw material according to market prices. Such raw material makes physical research on the "textile unit" a most uncertain and despondent field when the results are interpreted according to the expectations of the spinner or manufacturer. To take an example, it is now known that the lustre of a doubled yarn depends on a certain relationship between the constants for spinning the singles and for doubling them. If this condition is not satisfied, it is easy to make a highly lustrous raw cotton into a less lustrous yarn than might have been produced by using a less lustrous cotton and working it properly. This is quite apart from the measurable characteristics of raw cottons, such as staple length, fineness, or convolutions, etc., and shows that the relative *position* of the fibres, determined by the spinning processes, is at least as important as the properties of isolated fibres. Again, the percentage irregularities of yarns spun from high- and low-grade cottons are about the same, so that this important property does not depend appreciably on the raw material. Such examples might be multiplied a hundred-fold. While not denying that many of the defects existent in yarns and fabrics are rightly concerned with variability in the raw material, it is necessary to emphasise the fact that many defects are traceable to the machines, scarcely one of

which, in the writer's opinion, cannot be improved by physical research. Dr. Balls' remark that "the utility of the scientist in industry is largely conditioned by the degree of stability of the industry" is only too true; it enforces the necessity for work on the complex mixtures of raw material almost universally used in practice, and leads us to the conclusion that work of this character is the more immediate. Furthermore, it is the duty of the Textile Industrial Research Associations to supply such practical information while still keeping a preserve for work on "textile units," which, it is hoped, will eventually be of vital importance to the producer of the raw material.

Dr. S. A. Shorter dealt with the nature of the recovery from strain of the wool fibre, in particular, attributing the creep to the combined effects of elastic and impeded elastic portions of the fibre structure rather than to its plasticity, to which property other authors have ascribed the effects. He stated that the elasticity of wool approaches the ideal, the hysteresis being almost entirely a true effect, and suggested that the fibre acts as a two-phase system, including (a) a perfectly elastic framework, (b) a viscous fluid; the two affording a complete explanation of the phenomena observed in the finishing of woollen and worsted fabrics. Mechanical models were described to illustrate the type of structure advocated, and the system of impeded elastic elements was used to explain how the shedding fault arises in a loom which has been standing over (say) the week-end.

Some experiments on loaded gelatin sticks were described by Mr. Pool, who concluded that the elastic effects observed in such purely colloidal systems were analogous to those simulated by Shorter's model. It was pointed out by Dr. Mardles that similar effects were common in many materials, *e.g.* steels, time and stress introducing new phases initiated by molecular changes. Mr. Peirce thought the effects were due to impeded but reversible orientations within the mass and these effects were ultimately inherent in the molecules themselves. In his paper on the fibre balance, Dr. Barratt described load-extension diagrams showing the relative degree of non-recovery from strain in wool, cotton, silk (viscose) and flax, the order, as indicated, being decreasing. Dr. Shorter was of the opinion that in the case of the wool fibre, practically all the residual strain would disappear by wetting, while he agreed that with cotton fibres a small amount of non-recovery persists.

Two important communications were made by Dr. T. Barratt on the lustre of cotton fibres and the transparency of fabrics. The lustre comparisons were made by a special arrangement of a Joly photometer, the fibre pads being so mounted that varying angles of incidence and diffusion could be obtained, and also so that they could be rotated in their own plane. Unmercerised and mercerised cotton and glass fibres were tested and the conclusions drawn that (1) the light reflected from a mercerised fibre in certain positions is concentrated within a small angle; (2) the light from an unmercerised (twisted) fibre is scattered over a wide angle; and (3) the lustre is enhanced when a number of mercerised fibres are laid parallel to each other (the case of a sateen with "floating" threads). The increased lustre shown by a mercerised fibre is due to light regularly reflected in a plane containing the length of the fibre. In keeping with this result, the work of the writer and Mr. Adderley was mentioned, which showed that in doubled yarns the optimum lustre was obtained when the fibres in the doubled yarn are parallel to its axis, so that, looking

along the yarn, the light is mainly reflected along the length of the fibres.

Using the Joly photometer, measurements of (1) the total transparency of fabrics (defined as percentage of incident light transmitted), (2) thread transparency (the percentage of light falling on the threads alone, which is transmitted), were made. The determination (2) was made possible by dyeing the threads black and so obtaining a measure of the light transmitted by the spaces alone. From the combined readings it is then possible to calculate the total light incident on threads *alone* and that transmitted by threads *alone*, which is a measure of thread transparency.

Mr. C. R. Nodder showed slides of the structural characteristics of compressed flax fibres, up to fifty daily growth rings being visible, and also the spiral fibrillæ in each layer. Herzog and Jancke have obtained X-ray point diagrams with flax and ramie fibres which they attribute to a rhombic (or monoclinic) symmetry of constituent crystallites. With powdered fibres they obtained diffraction rings confirming this result. Flax and ramie fibres subjected to similar compression presented optical effects which indicate the true crystalline nature of their structure.

A large number of physical data relating to the silk fibre (the ultimate filament of fibroin, two of which, gummed together by sericin, form the cocoon thread) were detailed by Dr. W. S. Denham. The most interesting of these concern the crystalline structure found by Herzog and Jancke. Some measurements on the lustre of silk fibres with the plane of incidence perpendicular and parallel to the fibre length were discussed in terms of the arbitrary expressions for lustre recommended by Zart, Schultz, and Adderley, and Dr. Denham reasonably advocated some universal standard. The lustre is greater with the plane of incidence containing the fibre length (cf. Barratt, *supra*). The thermal conductivities of textiles have been measured by Miss Rood; the values, for the same density, increasing in the order, silk, wool, artificial silk, linen, and cotton.

An interesting account of experiments on the tautness of aero-fabrics was given by Dr. Ramsbottom, who pointed out that though dope may be regarded as the primary factor in fixing tautness, still the nature of the fabric is of importance in maintaining this property at high humidities and after long exposure. Fabrics woven from fine yarns preserve tautness better than those containing coarser yarns, and linen, cotton, and silk all give satisfactory tautness at low humidities. With cotton and linen, at high humidities the tautness falls but recovers with absorption of water by the fabric, whereas with silk the tautness falls off continuously, so that silk fabrics are inferior to others. Mercerised cotton is preferable to unmercerised cotton or linen. Measurements on strength and deterioration on weathering were given. Dr. de Waele asked if it were possible to obtain a mesh of (say) silk and cotton which would have constant tautness, in reply to which Mr. Crompton said it was quite feasible to double artificial silk and cotton to test this point.

The action of light on textiles was discussed by Dr. Barr, who laid stress on the difficulties of measuring the photochemical action due to sunlight, which is the real aim of such research. With sunlight the spectrographic method has given negative results, while only incomplete data have been obtained by using glass screens. The method of first dyeing the fibres and exposing them to white light has given some practical results, but these are difficult to interpret, being complicated by the ill-defined nature of the light stimulating the reaction and the possibility of unknown interaction between fibre, dye, and the reaction products.

With the mercury arc in quartz, rapid deterioration of textile fibres may be developed, but such effects cannot be safely translated into terms of sunlight. Cellulose is very sensitive to wave-lengths less than 3000 Å.U., which exist in the mercury arc but not in sunlight. Aston's work on cotton and linen threads (for aero-fabrics) indicates that with light from the mercury arc, the most destructive rays have wave-lengths less than 3990 Å.U., a conclusion which has been verified by Ramsbottom by using coloured glass screens. Two hundred hours' exposure to sunlight produced no effect. Assuming that ionised oxygen is responsible for the deterioration, Lindemann has deduced from the quantum theory that the most destructive radiation has a wave-length of 3230 Å.U.

Very little is known about the tendering action of light on other textile fibres. Silk appears to be considerably more affected than linen, while wool is almost immune.

Mr. F. D. Farrow referred to some recent advances in the experimental study of warp sizing, and dealt with the work of Owen and New on the oscillating resisting properties of yarns, and that of Farrow and Lowe on the viscosity of starch pastes. The work on viscosity involves a modified Poiseuille's equation, a "coefficient of flow" being measured which is proportional to a power of the pressure, the index varying between 1 and 2.

A review of the recent work on the moisture relations of textile materials was contributed by Mr. A. R. Urquhart and Dr. A. M. Williams. The hysteresis effects observed in the authors' work have been interpreted in terms of Zsigmondy's theory of the existence of capillary spaces within a gel, which, in the case of cotton, have a diameter of the order 13×10^{-8} cm. A study of the rates of absorption and desorption indicates that these processes are discontinuous.

A paper on the effect of water in the wet-spinning of flax was given by Dr. W. H. Gibson, who held the view that the process was conditioned by a gradual variation in the fibre constitution from pectin through intermediate products to cellulose. There is apparently a considerable breakage of the fibres (about 12 in. long) with a drafting reach of $3\frac{1}{4}$ in., as might be expected, and frequency curves showing the displacement of the breaking load modes of the yarn and rove confirm this.

In addition to the papers submitted for discussion, a number of interesting slides of linen fabrics from Tutankhamen's tomb were exhibited by Dr. A. Scott. These depicted (a) a linen veil, unbleached, 150-160 threads per inch $\times$ 80 threads per inch, in reflected and transmitted light; (b) a pall of much coarser linen fabric; and (c) a very friable linen fabric having two threads one way and one the other.

Sir Robert Robertson pointed out the great importance of obtaining further knowledge of the action of light on fabrics, and Mr. Lester remarked that we knew next to nothing about the life of a fabric, recalling the process of laundering and the effect of acid. In a few months a fabric might lose 60 per cent. of its strength.

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University and Educational Intelligence.

BIRMINGHAM.—The degree of Ph.D. has been awarded to the following candidates, the subjects of the theses being indicated in each case: Mr. N. F. Budgen (Researches with cadmium); Mr. Denis Bunting (An investigation of the brittle ranges of brass); Mr. Kamil Iskander (The development of precision measuring instruments for the determination of the heating value of gases); Mr. T. D. Jones