INTRODUCTION

FIBRES FOR CLOTHES

During the early days of his existence, man depended upon animal skins and furs to keep him warm. But as the years passed, his susceptibilities became more tender and his hide less coarse. A sheepskin wrapped carelessly round the body may be better than nothing for keeping out the cold – but only just. Inflexible and uncomfortable, it would not fit *homo sapiens* as well as it had the sheep.

Inevitably, man began to look around for something that would keep him warm more elegantly and more comfortably than an evil-smelling hide. At some point in history, he found that the long thin fibres produced by plants and animals could be twisted together to form a thread. These threads could then be interlaced to provide a flexible, warm and supremely comfortable material such as he had never known before. He had discovered cloth.

Natural Fibres

Since those early days, all the hundreds of different sorts of natural fibre have been collected and examined as potential raw materials for cloth. The hairs of animals like the sheep; the 'stringy' portions of plants ranging from the coarse backbone of the nettle stem to the fine seed-fibre of the cotton plant; the delicate filaments formed by insects and other creatures, like the spider's web or the cocoon of the silkworm – all these can be twisted together to form a thread and then woven into cloth.

In their basic properties – their fineness and flexibility, their resilience and shape – these natural fibres vary widely, and the types of cloth they provide are correspondingly diverse. But in general, cloth possesses certain common and altogether satisfying characteristics that have made it into one of the essential materials of our modern world. Cloth is strong and yet sufficiently supple to take up the peculiar contours of the human body. Made into clothing it is hard-wearing and yet permits free movement; it is warm, but at the same time does not seal up the body and prevent its breathing.

As textiles have developed over many hundreds of years, the most suitable natural fibres have been selected and have become the basis of the textile industries of the world. Today, as for many years past, cotton, wool, jute, flax and silk are the most important of our natural textile fibres, with a number of others doing relatively unimportant jobs.

Upon these few natural fibres, man has depended for centuries for the clothes that keep him warm. Prior to the Industrial Revolution, spinning and weaving were accepted routines of daily life in every home, and the making of fibres into textiles remained a household industry. It was a craft, a skilled occupation of working people who handed down its secrets from one generation to the next.

Spinning

The first fundamental process in making cloth is spinning, which is one of the oldest industrial arts in the world. Spinning converts a mass of short fibres into long threads or yarns suitable for weaving together into cloth. For thousands of years, the techniques of spinning natural fibres altered little. Hand-spinning was a process that depended on manual dexterity and skill, using the very simplest of mechanical devices. It is only in the last two hundred years that spinning machines have transformed the production of yarns and threads into a mechanized industry.

Though hand-spinning developed simultaneously in many parts of the world, and many different fibres were used, the simple spinning instrument – the spindle – is basically the same no matter where it comes from. The spindle is little more than a piece of smooth, rounded wood about a foot long, tapered at each end and weighted with a little disc of wood, clay or stone in the middle. The latter acts as a flywheel, giving momentum and stability to the spindle as it rotates.

At one end of the spindle there is a little notch in which the fibres are caught up as they are being twisted into yarn. The spindle is rotated by being rolled against the leg, or it is simply twirled between the fingers. As the twisted yarn is formed, more fibres are pulled out steadily from the mass of wool or cotton or other fibre until a length of yarn has been produced. This stretch of yarn is then wound up onto the spindle shaft and the process is repeated.

In this way, the simple hand spindle was used for centuries to produce continuous lengths of yarn from the masses of animal or vegetable fibres that nature made available. In the hands of an expert craftsman, the spindle could – and indeed still can – provide yarns of incredible delicacy and uniformity. The wonderful Indian muslins were once made entirely from cotton spun so fine on hand spindles that 28g (1 oz) of fibre would make 15m (50 ft) of yarn. The spindle was a thin length of bamboo cane weighted with a small disc of clay.

By the fourteenth century, the first steps towards mechanization had been taken. In India and Europe, the spinning wheel had been developed. This was a simple instrument in which the spindle was mounted horizontally in a wooden frame. The little flywheel in the centre of the spindle was converted into a pulley by cutting a groove in the rim. A leather thong was passed round this pulley and round a larger wheel; when the larger wheel was turned with the left hand, the spindle rotated much faster than it could be spun directly in the hand. Fibres were fed to it by the right hand of the spinner, and twisted into yarn in the usual way. When an arm's length had been made, the yarn was held at right angles to the spindle and wound up onto it. Then a further arm's length was made, and so on until a bobbin of yarn had been formed on the spindle shank.

By the sixteenth century the spinning wheel had been fitted with a treadle, leaving the operator with both hands free for manipulating the threads.

Weaving

The yarns made with these simple manually-operated spinning machines were converted into cloth by being woven on hand-looms. The loom is a device in which yarns can be criss-crossed or interlaced and so built up into a textile fabric. The simplest of all fabrics is a plain cloth in which rows of threads at right-angles to one another pass over and under each other alternately. Cloth of this sort is made on a hand-loom in which every alternate thread running lengthwise (the warp) is lifted and the remaining threads are lowered. A transverse thread (the weft or filling) is passed between the two sets of warp threads, whose positions are then reversed. In this way, the transverse thread is locked in place, passing over and under alternate threads in the warp. All manner of variations can be superimposed upon this simple theme, enabling the skilled weaver to create an immense variety of intricate weaves in his fabric.

Hand-loom weaving was the second stage in the production of cloth by village communities. The weaver was a local craftsman who enjoyed a status similar to that of the carpenter or the blacksmith.

Textile manufacture thus became a trade based on traditional experience and skill. It remained an occupation of the ordinary people, who had neither the time nor opportunity to pay attention to the fundamentals of their trade. Pure science before the days of steam was seldom linked with mundane occupations such as the processing of fibres into textiles.

During the eighteenth century, the Industrial Revolution swept over Britain as steam began to turn the wheels of industry. And what trades could be better served by steam than spinning and weaving? Steam engines took over from the water-wheels in mills that had been built beside the Pennine valley streams. Gradually, the spinning wheels and looms were abandoned in the cottages as their owners migrated to the great steam-powered mills in the valleys of Lancashire and in the Yorkshire dales. Throughout the nineteenth century, Britain's textile industry thrived and became the mainstay of the country's trade. Steam power allied with engineering invention transformed the old crafts into an industry whose market was the world.

Scientific Renaissance

This same century was to see a renaissance of science in Britain which followed John Dalton's development of the atomic theory in 1808. But science was slow to reach the textile trade; the manufacturers were too busy turning out their goods to worry unduly over the whys and wherefores of their raw materials. Nature had provided cotton and wool, flax and silk; surely it was now up to man to make the best use of them that he could?

So, during most of the nineteenth century, textile progress lay not so much in the integration of the industry with advancing scientific knowledge, but in the continued application of inventive and engineering skill to the spinning and weaving processes.

It was on this basis that Britain's textile industry built itself to greatness in Victoria's reign; and even by the beginning of the present century knowledge of the fundamental structure of the textile fibres remained scanty and uncertain.

It is only during the last fifty or sixty years that science has really begun to play a major role in the textile industry. As we have learned something of the chemistry and physics of textile fibres, so we have been able to create a range of completely new fibres which have changed the entire outlook of the textile trade. Rayon, nylon and other man-made fibres are being manufactured in enormous quantities and nature's monopoly of textile fibre production has been broken.

Today, the importance of research and scientific understanding in the textile industry is established. The fibres on which the entire industry is based are the subject of a vast amount of academic and industrial research. Textile progress is no longer dependent simply on inventiveness and engineering skill; textile manufacture has become a modern scientific industry that must keep abreast of scientific progress and discovery.

The 'big four' – cotton, wool, flax and silk – are still used more extensively than any other natural textile fibres. But the manufacture of rayon and synthetic fibres has attained the status of a major world industry, and output is increasing. Moreover, the discovery of nylon stimulated research on synthetic fibres which has given us a range of synthetic fibres which increases year by year.

What is a Textile Fibre?

The use of textiles for clothing and furnishing depends upon a unique combination of properties. Textiles are warm; they are soft to the touch; they are completely flexible and thus take up any desired shape without resistance; and they are usually hard-wearing.

The reason for these properties is to be found in the structure of textile materials. Textiles are derived from threads or yarns which have been interlaced in one way or another. The threads themselves are flexible, and in their loose interweaving they remain flexible, conferring this property on the cloth itself.

In their turn, the threads or yarns are built up by twisting together the long, thin, flexible but strong things we call fibres. Ultimately, therefore, the properties of any material must depend very largely on the properties of the fibres from which it is made. The spinning and weaving processes obviously have their effect on the final textile. A worsted suit, for example, bears little superficial resemblance to a baby's cardigan, though both are made from wool. But the basic natures of the two garments are similar, and are a consequence of the fact that each is made from wool.

For a fibre to be suitable for textile purposes, certain qualities are desirable; others are essential. First, to be a fibre at all, the length must be several hundred times the width. It is this that enables fibres to be twisted together to form a yarn or thread.

In addition, the fibre must be strong and yet extremely flexible. Strength is needed to enable it to withstand the spinning and weaving processes, and to provide strength in the final cloth. Flexibility permits the fibres to be spun and woven, and gives to a textile its unique draping characteristics.

The actual length of the fibre is important. It can be infinitely long, but should not be shorter than 6 – 12mm (¼ – ½ in), or it may not hold together after spinning. The width of the fibre can vary between considerable limits, and it is upon this that the fineness of the material eventually depends. Silk, for example, is a fine fibre and yields a delicate cloth; jute is a coarse fibre that is largely used for making sacks.

In addition to having strength and flexibility, a textile fibre should be elastic. Brittleness leads to poor wear in the garment; elasticity allows the material to 'give' when subjected to a stretching force.

Waviness, or crimp, is a natural feature of certain fibres such as wool. It affects the 'holding together' power of the fibres in the spun yarn and controls the porosity and warmth of the fabric.

The ability of a fibre to absorb moisture influences the hygienic qualities of the cloth. Fibres that cannot absorb moisture may help to make the cloth feel clammy when it is worn.

The weight of a fibre affects the draping qualities when it is made into a cloth. If the fabric is too light, it may not drape well; yet if it is too weighty, the material will be heavy and dull.

With all the variability possible in these important properties, it is not surprising that we find such diverse characteristics in the natural fibres. Nor is it reasonable to expect that anything that looks fibrous will be suitable for making into textiles.

When we add to these requirements the essentials of abundance and cheapness, we find that the number of fibres suitable for large-scale textile use has narrowed down to relatively few.

Some of them, like cotton and flax, are vegetable fibres which nature uses for some essential purpose in the growing plant; others, like wool or silk, are produced by the animal world.

Classification*

The fibres used in modern textile manufacture can be classified into two main groups (a) natural and (b) man-made fibres. The natural fibres are those, such as cotton, wool, silk and flax, which are provided by nature in a ready-made fibrous form. The man-made fibres, on the other hand, are those in which man has generated a fibre for himself from something which was not previously in a suitable fibrous form.

* See chart on page xxvii.

NATURAL FIBRES can be subdivided into three main classes, according to the nature of their source.

(a) Vegetable fibres
(b) Animal fibres
(c) Mineral fibres

Vegetable fibres include the most important of all textile fibres – cotton – together with flax, hemp, jute and other fibres which have been produced by plants. They are based on cellulose, the material used by nature as a structural material in the plant world.

Animal fibres include wool and other hair-like fibres, and fibres, such as silk, produced as filaments by cocoon-spinning creatures. These animal fibres are based on proteins, the complex substances from which much of the animal body is made.

Mineral fibres are of limited importance in the textile trade. Asbestos is the most useful fibre of this class; it is made into special fire-proof and industrial fabrics.

MAN-MADE FIBRES can be sub-divided into two distinct classes, according to the source of the fibre-forming substance from which they are made.

(a) Natural polymer fibres
(b) Synthetic fibres

Natural polymer fibres are those in which the fibre-forming substance has been made by nature. Vast quantities of cellulose, for example, are available to us in the plant world. Only a small fraction of this cellulose is used by nature for making fine fibres such as cotton. Most of it is used as a structural material, for example in the trunks of trees and the skeleton framework of stems and leaves. This cellulose is largely useless to us as a direct source of textile fibres; it is in fibrous form, but is contaminated with other substances.

In the last half-century or so, we have learned how to manipulate this natural cellulose into a form suitable for use as textile fibres. It is the source of the fibres which became known as artificial silks.

In these natural polymer fibres nature has done the work of creating a substance (cellulose) capable of taking on a fibrous form. Man has merely taken a further step by using this cellulose as raw material for a fibre.

In a similar way, it has been possible to use materials made by animals as a source of man-made fibres. The proteins used for so many structural purposes in the animal world are often capable of forming fibres. Nature has produced the proteins without necessarily using them for fibres. Man has then taken these proteins and manipulated them into a fibrous form. So we have natural polymer fibres made from the proteins of peanuts and milk, maize and soya beans.

Synthetic fibres, on the other hand, are those in which man has performed the entire operation of fibre-production without allowing nature to manufacture the fibre-forming substance. Nylon, 'Terylene' and 'Orlon' are fibres made by man from simple chemicals such as those derived from coal or oil. These chemicals have been made into materials capable of forming fibres, and these materials have then been manipulated into a fibrous form. Man has carried out the entire operation. Nature has had no hand in the production at all. They are truly synthetic fibres.

This is the system of classification that has been followed in this book. Volume I deals with the Natural Fibres in the sequence Vegetable, Animal and Mineral; Volume II deals with Man-made Fibres, (a) Natural Polymer and (b) Synthetic.

ORGANIZATION OF INFORMATION

Throughout the book, every fibre has been considered as far as possible in the same way, the information being included in four sections:

(a) Introductory Section
(b) Production and Processing
(c) Structure and Properties
(d) The Fibre in Use

(a) INTRODUCTORY SECTION

In this section, the history of the fibre is outlined, showing how it has attained its present-day status in the textile industry. Commercially-available grades are described, with reference in particular to their basic characteristics of fineness and length.

FINENESS may be measured in several ways, the most direct method being to quote the thickness of the fibre in microns ($\mu = 0{\cdot}001$ mm.). In practice, it is usual to express the fineness of a fibre in terms of the mass per unit length, e.g. in milligrams per kilometre (millitex units) or as the weight in grams of 9,000 metres of the fibre (denier). Fineness may also be expressed in grams per centimetre, e.g. in units of 10^{-6} g/cm.

In addition to these numerical methods of expressing fineness there are other techniques which have become established in the textile industry. Wool fineness, for example, is described by a system of grades which are related to the finest yarn counts which can be spun from the fibre in question. Cotton, likewise, is graded in fineness according to the resistance of a sample to the flow of air through it (micronaire values).

LENGTH is a most important factor in assessing the value of a fibre. Most natural fibres are of limited length, commonly a few millimetres to several centimetres. Silk is the exception, being formed as filaments which may be 2km or more in length. Synthetic fibres are produced as continuous filaments which may be used as such or chopped into shorter 'staple' fibres for spinning by processes similar to those used in spinning natural staple fibres such as cotton or wool.

The staple length of a synthetic fibre is controlled by the manufacturer, who can cut the filaments into any length he wishes. The short fibres may be all the same length, or they may consist of a mixture of fibres of different lengths blended in known proportions.

In the case of a natural fibre, staple length is a much less easily defined characteristic of any batch of fibre. A mass of wool or cotton, for example, will consist of fibres varying in length over a wide range. No two batches of natural fibre are ever alike, and the staple length and fineness cannot be quoted with numerical precision as in the case of a synthetic fibre.

The assessment of the staple length of a natural fibre is an assessment of the technically most important length of fibre in a sample. It may be determined by carrying out a statistical examination of the fibre lengths in the laboratory, but it is in practice often the responsibility of a skilled assessor who draws upon long experience in examining any batch of fibre and estimating its effective staple length.

(b) PRODUCTION AND PROCESSING

In this section, an account is given of the methods used in producing the fibre, whether it be a natural fibre that is grown or a synthetic fibre that is made in chemical plant. This is followed by notes of special treatments the fibre may undergo during its processing into yarn and fabric.

Included in this section is a note on dyeing which is intended to highlight features of the dyeing properties rather than to describe the dyeing techniques in detail. Dyeing is a complex and highly skilled art, and detailed procedures are described in other books.

(c) STRUCTURE AND PROPERTIES

This section summarizes the important characteristics of a fibre under a series of sub-headings.

(1) FINE STRUCTURE AND APPEARANCE. The surface structure of a fibre is most important in that it controls the behaviour of the fibre in the yarn or fabric. The rough scaly surface of wool, for example, influences the felting and shrinkage properties of wool fabrics, and helps to give wool its characteristic handle. The scales enable individual fibres to grip one another when twisted together as a yarn. The convolutions of the cotton fibre, similarly, enable fibres to grip one another when spun.

The smooth, glassy surface of a fibre such as nylon, on the other hand, affects the lustrous appearance of the fabric. Smooth surfaces may not cling to dust and dirt so readily as rough surfaces do.

The cross-sectional shape of a fibre has an important influence on its behaviour in a textile fabric. Fibres of circular or near-circular cross-section often have an attractive handle. Wool, for example, is a fibre of near-circular cross-section; it has a more 'comfortable' feel than cotton which has a flatter, ribbon-like cross-section. 'Orlon', on the other hand, which has a dog-bone cross-section, has a very good handle.

Circular fibres often have a poorer covering-power than the flatter fibres.

Diagrams showing the microscopic appearance (cross-sectional and longitudinal) are provided for many fibres.

(2) TENSILE STRENGTH. This is the breaking strength of any material, which is commonly expressed as force per unit cross-sectional area, e.g. as dynes per square cm. In these terms, we may describe the ability of a bundle of fibres, or a yarn, to resist breakage under tension.

When a single fibre is being considered, the strength of the fibre is commonly described as *tenacity*, which is a measure of *specific stress* at break,

$$\text{i.e. } \frac{\text{breaking load}}{\text{mass per unit length}}$$

Tenacity is expressed in terms of grams per decitex or centinewtons per tex (cN/tex).

Two fibres with identical tenacities may have different tensile strengths; if their densities are different, the cross-sectional areas will be different too.

(3) ELONGATION. When a fibre is subjected to a force, it will stretch to a certain degree. This stretching is described as elongation or extension, in terms of a percentage of the fibre's original length. It can be measured either as an elongation under a certain load, or as the elongation reached when the fibre breaks. Unless specified to the contrary, the figure given represents the elongation at break.

(4) ELASTIC PROPERTIES. *Elastic Recovery*. When a fibre is stretched by a small amount, it may exhibit almost perfect elasticity. That is to say, it will return to its original length when it is released. The *elastic recovery* in this case is 100 per cent. If, however, the fibre is subjected to a greater degree of stretch, it may react in a much more complex way. Some permanent deformation may take place, so that when it is released the fibre will return to an elongated form. It recovers from some of its elongation, but not all.

This behaviour of a fibre can be denoted by describing its elastic recovery at certain elongations (specified as percentage of original length). Thus, in the case of a fibre which returns completely to its original length after, say, a 2 per cent elongation, we can say that the elastic recovery is 100 per cent at 2 per cent elongation. In the case of a fibre which retains half its extra length after release from an 8 per cent elongation, we say that it has a 50 per cent elastic recovery at 8 per cent elongation.

The elastic properties of a fibre are normally defined only with limited usefulness in this way. The recovery of a fibre, for example, depends upon the length of time it is held in the stretched position. Also, the degree to which it recovers depends on the time between its release from tension and the taking of the measurement.

Stress-Strain Diagram

The tensile and elastic properties of a fibre are usually summarized in a *stress-strain diagram*. In this diagram, the strain (i.e. the distortion in the fibre) is plotted against the stress (i.e. force) exerted on the fibre. A stress-strain diagram gives a much more complete record of the behaviour of a fibre under tension than isolated figures can.

Typical stress-strain diagrams are provided for many fibres.

A straight line on the stress-strain diagram may indicate that the fibre is truly elastic. The extension of the fibre is proportional to the applied load. This is, however, rarely achieved in practice. As the load on a fibre increases beyond that needed to cause a few per cent extension, the deformation of the fibre is greater than that due to true elasticity. Superimposed upon the 'elastic' stretch there is some more or less permanent deformation of the fibre, or plastic flow.

As the tension increases, the stress-strain curve indicates how the fibre continues to deform up to the point at which it eventually breaks.

The stress-strain diagram therefore provides a much more complete picture of the deformation caused in a fibre as tension is applied to it. The diagram includes tenacity and elongation at break. Elastic recovery and the slow recoverable deformation described as 'creep' are determined from a number of stress-strain diagrams where repeated stresses are given, and the return paths measured.

The stress-strain behaviour of a fibre is of great importance in practice, and influences to a large degree the behaviour of the fibre in textile manufacture. During processing of the fibre into a yarn and weaving of the yarn to fabric the fibres are under varying degrees of tension. They should be able to withstand these tensions without stretching permanently to any great degree.

Wool is unusual in that it can stretch by 35 per cent and will return to its original length when relaxed. Cotton, on the other hand, has an extension at break of only about 5–10 per cent.

The general reaction of a fibre to longitudinal tensions and to flexing backwards and forwards has an immense influence on the properties of the cloth made from the fibre. A resilient fibre such as wool will tend to return to its original shape after a fabric has been crushed or creased. The crease-resistance of a fabric is usually a consequence of the resilience of the fibre itself.

Work of Rupture. The area below the stress-strain curve provides a measure of the energy needed to break the fibre. It indicates the ability of the fibre to withstand sudden shocks, and is measured in grams per decitex or centinewtons per tex.

Initial Modulus. This is a measure of a fibre's resistance to small extensions. A high modulus means that the fibre has a good resistance to stretching, and a low modulus means that it requires little force to stretch it. Flexibility and modulus are closely linked, a low-modulus fibre tending to be flexible, and a high-modulus fibre tending to be brittle.

Average Stiffness. This is the ability of a fibre to carry a load without deformation. It is based on the modulus of elasticity, and is expressed as grams per dtex or cN per tex.

Average Toughness. This is the ability of a fibre to endure large permanent deformations without rupture. It is expressed as grams per dtex or cN per tex.

(5) SPECIFIC GRAVITY. This is a measure of the density of a fibre; it is the ratio of the mass of a material to the mass of an equal volume of water at 4°C. This is an important characteristic of any fibre; it affects the way in which a fabric will drape.

(6) EFFECT OF MOISTURE. All fibres tend to absorb moisture when in contact with the atmosphere. The amount absorbed depends upon the relative humidity of the air.

In practice, the moisture-absorbing properties of a fibre are described by a figure known as the 'regain'. This is the weight of moisture present in a textile material expressed as a percentage of its oven-dry weight (i.e. the constant weight obtained by drying at a temperature of 105 to 110°C.).

The 'percentage moisture content' of a fibre is the weight of moisture it contains, expressed as a percentage of the total weight. This is a measure of the amount of water held under any particular set of circumstances.

Fibres vary greatly in the amount of moisture they will absorb. Wool, for example, has a regain of 16 per cent, acetate of 6 per cent and 'Dynel' 0·4 per cent. A fibre which absorbs water readily is often most suitable for use in certain types of clothing fabrics. These fabrics will absorb perspiration from the body and will hold considerable amounts of water without feeling clammy. The ability of a fibre to absorb moisture will also affect the processing and finishing of yarns and fabrics. Dyestuffs are generally able to penetrate a moisture-absorbing fibre much more easily than they will penetrate a fibre that does not absorb much moisture.

The new synthetic fibres, which often have a very low moisture regain, are easily washed and dried by comparison with fibres which absorb a lot of moisture. On the other hand, they tend to accumulate charges of static electricity much more readily than the moisture-absorbing fibres.

The tensile properties of a fibre are affected significantly by the water it absorbs. A fibre which absorbs water freely will usually suffer a loss in tensile strength when wet. (Cotton is an exception.) Elongation at break is also increased.

As fibres absorb moisture they may swell to a considerable degree.

(7) THERMAL PROPERTIES. All fibres are affected in one way or another as they are heated. Some, like wool, will begin to decompose without melting; others, like polyethylene or acetate will soften and melt before decomposition sets in. The behaviour of fibres on heating is of real importance, particularly within the range of temperatures that are met in practical use. Fabrics should, for example, withstand the temperatures used in laundering and ironing without undue deterioration.

Many of the new synthetic fibres are thermoplastic substances; that is to say, they will soften as they are heated. The temperature at which they soften largely determines their practical usefulness in the textile field.

In the presence of air, most fibres will burn. The readiness with which they catch fire and support combustion is of immense importance. Many accidents are caused every year by clothing catching fire, and there is an increasing realization of the need for reducing the flammability of textile fibres and fabrics.

(8) EFFECT OF SUNLIGHT. Almost every fibre is affected by the powerful radiations of sunlight. Some will decompose and deteriorate fairly rapidly, losing tensile strength and changing colour. Others will resist deterioration for years, and are particularly useful for fabrics such as curtains, awnings and furnishings which are constantly exposed to light.

(9) CHEMICAL PROPERTIES. Modern techniques of processing fibres, yarns and fabrics often involve the use of chemicals in great variety. Bleaching agents, detergents, alkaline scouring agents, dyeing assistants and other chemicals are used in preparing the finished textile. The fibre itself must be able to withstand these substances without suffering harmful effects.

(10) EFFECT OF ACIDS. Textiles are commonly subjected to acid

solutions of one sort or another, and the effects of different acids under varying conditions are important.

(11) EFFECT OF ALKALIS. From the very earliest times, alkaline agents have been used for washing and scouring textiles. Soap itself forms an alkaline solution in water.

(12) EFFECT OF ORGANIC SOLVENTS. The introduction of dry-cleaning has made solvent-resistance of great importance in a textile. Solvents such as carbon tetrachloride and trichloroethylene are commonly used for cleaning fabrics, and the effect of these solvents on the fibre itself is obviously important.

(13) RESISTANCE TO INSECTS. The cellulose of plant fibres and the protein of wool and other animal fibres are substances produced by living things. They are, as might be anticipated, enjoyed by other living things as food.

Wool suffers more than other fibres from the fact that it is eaten by certain types of moth grub and beetle. Many fibres, particularly the synthetics, are not attacked in this way.

(14) RESISTANCE TO MICRO-ORGANISMS. Cellulose is attacked by certain moulds and bacteria, which decompose it and make use of the degradation products as food. Textiles stored in damp warehouses are often affected by mildews, which may discolour and weaken the fibres to the point at which they become useless.

(15) ELECTRICAL PROPERTIES. The dielectric strength of a fabric is important if the material is to be used for insulation purposes in the electrical industry. It also influences the degree to which static electricity will accumulate on a yarn or fabric during processing or wear. Static electricity may be produced by friction between the yarns or fabrics and the surfaces they meet on processing machinery. The electricity often causes serious difficulties by entangling or misaligning yarns on machinery and attracting dust and fluff to the finished fabric.

The electrical resistance of a fibre may be described in terms of the mass specific resistance, i.e. the resistance of a 1 gram specimen 1 cm. long.

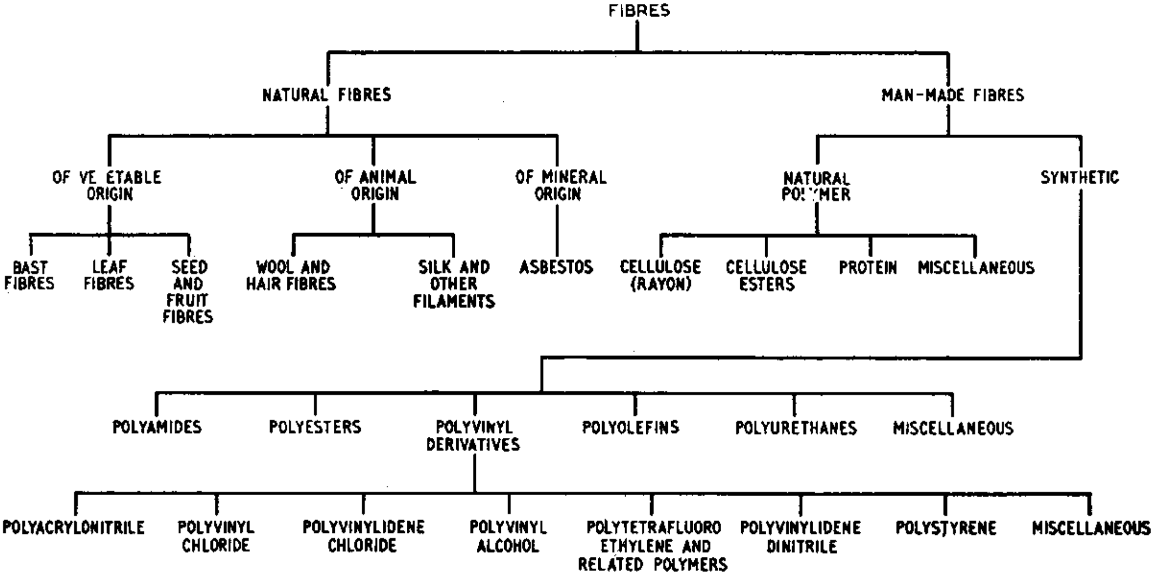
The production of static electricity is affected greatly by the moisture-absorbing characteristics of the fibre. A damp fibre will conduct electricity away as it is formed, so that pools of static do not collect on the fibre.

These properties can be regarded as fundamental characteristics of a fibre, and they are discussed in the 'Structure and Properties' section of each important fibre.

(d) THE FIBRE IN USE

In this section, the influence of the properties of the fibre on its behaviour in practical use is considered.

FIBRE CLASSIFICATION CHART



NATURAL FIBRES

A: OF VEGETABLE ORIGIN

B: OF ANIMAL ORIGIN

C: OF MINERAL ORIGIN