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THE

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A HANDBOOK ON

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BY

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PREFACE.

THIS book is written to give information on the Textile Fibres that are used in the various industries of the world.

In preparing it for publication, I have felt that there is need for information on this subject, if only to clear up obscure ideas that are prevalent as to the plants that produce the plumose or bastose fibres used in commerce.

In honouring me by the request to prepare this work, my publishers had in view the want that exists for a text and reference book on the processes by which fibres are obtained, and the purpose for which they are used in the different industries of commerce.

Most of the illustrations are from photographs or sketches from actual examples, made by myself, assisted by a few friends. My thanks are specially due to Sir William T. Thistleton Dyer, Director of the Royal Gardens, Kew, for the very many facilities he has given me during my visits to Kew. Also to Dr. Daniel Morris, Assistant-Director of the Royal Gardens, for his identification of certain doubtful species of fibres.

In my numerous visits to the Economic Museums at Kew, I have received valuable information and the kindest of attention from Mr. John R. Jackson, Keeper of the Museums, Mr. J. Hillier, the Assistant-Keeper, and Mr. Irving, head of the Herbaceous Department.

I also thank those who are mentioned in the text or have furnished me with specimens, as well as the following who have

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helped in various ways: Mr. Thomas Hallam, J.P., Cotton Spinner; Mr. Charles Timothy Bradbury, J.P., Managing Director of Gartsides of Manchester, Limited; Mr. Daniel F. Howorth; Mr. D. H. Wade, Director, Heginbottom Technical School; Mr. John Green; Mr. Ira Marsland; Mr. J. C. Wilson; and Mr. James Beaumont, of Ashton-under-Lyne; also to Mr. John E. Sunderland, of Rylands & Sons, Limited, Manchester; Professor Weiss, Owens College, Manchester; Mr. Thomas Axon, Heaton Norris, Stockport; Mr. C E. Flowerdew; Mr. Reginald Marsland; and Professor J. Reynolds Green, F.R.S., London.

In conclusion, I shall be grateful for any suggestions that will enable me to add to the utility of this work.

34 Camp Street,
Ashton-under-Lyne,
March, 1902.

LIST OF ILLUSTRATIONS.

THE TEXTILE FIBRES OF COMMERCE.

INTRODUCTORY.

THE vegetable and mineral fibres of commerce may be arranged in four groups, viz.—I. Plumose Fibres; II. Stem and Leaf Fibres; III. Fruit Fibres (all derived from plants); and IV. Mineral Fibres. These groups are represented by the fibres used in various important industries, and by other vegetable fibres, which at present are of special interest from a scientific point of view only.

I. Plumose Fibres.—The fruits and seeds of many British plants have plumose cell fibres, by whose aid they are wafted considerable distances, so as to ensure that some, at least, shall find the conditions favourable for their development.

This is the case with the fruits or seeds of Willow Herbs (*Epilobium*), Traveller's Joy (*Clematis*), Goat's Beard (*Tragopogon*), Thistles (*Carduus* and *Cnicus*), Butter Burr (*Petasites*), Dandelion (*Taraxacum*), Willows (*Salix*), Poplars (*Populus*), Grasses (*Gramineæ*), Ostrich Feather (*Arundo*), Club or Bulrush (*Scirpus*), and Reed Mace (*Typha*). In other countries similar structures occur in the Kapok (*Eriodendron*), Mudar or Yercum Silk (*Calotropis*), Wool Tree (*Ochroma*), Devil's Cotton (*Abroma*), Kumbi or Galgal Silk (*Cochlospermum*), *Bignonia* and Swallow Wort (*Asclepias cornuti*).

Fig. 1 represents four seeds of the winged Bignonia (nat. size). The outer portion of each seed is formed by a thin, almost transparent membrane which supports long fine hairs. In all cases the seeds are produced in great abundance, and may probably be utilizable for such purposes as for stuffing light pillows, for decorations, and for ornamentation.

The British plumose seeds belong to several genera, and are usually abundant enough to make their collection easy. A systematic trial of their useful properties would probably give rise to several profitable and important commercial results.

The plumose hairs of cotton seeds are the most important as yet known to commerce. They are principally used for the spinning of yarns from which cotton cloth is woven.

Those of silk cotton are chiefly used for articles of upholstery, such as cushions, pillows, saddles, and as a substitute for down in the eider-down quilt and other manufactures.

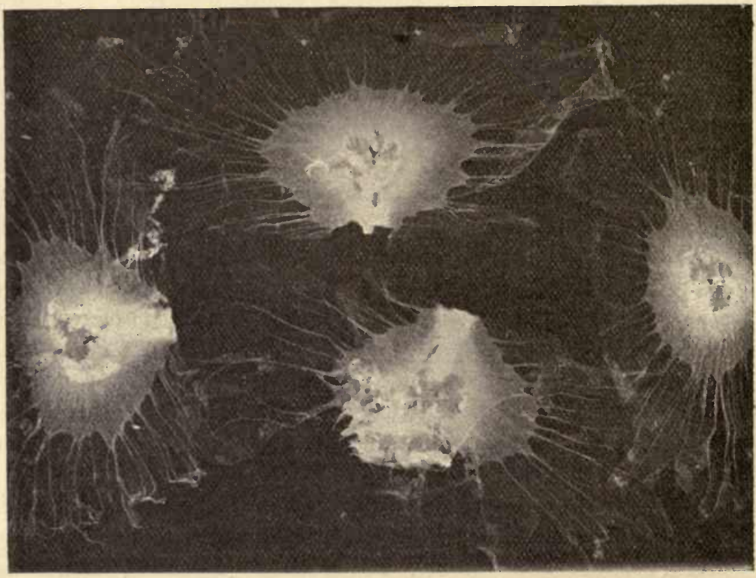

Fig. 1.—Seeds of winged Bignonia (nat. size).

Some silk cotton hairs and others obtained from the pod of the Wool Tree have been recommended as suitable for mixing with animal fur-fibres for felting purposes in the manufacture of fur and silk hats.

II. Stem and Leaf Fibres.—Stem fibres are obtained from the cortex or bast portions of the stems of dicotyledonous plants, such as Flax, Hemp, Jute, and Ramie or China Grass. In monocotyledonous plants the fibres are derived from the sheaths which enclose the vascular bundles of the stems, as in Bhabur grass and Esparto grass. Leaf fibres are chiefly obtained from the petiole or lamina of monocotyledonous plants, such as the various species of Agave or Aloe, *Phormium tenax* or New Zealand Hemp, *Agave heteracantha*, the Mexican fibre largely used for brush-making, and the *Musa textilis* or Manila hemp, a cordage fibre plant.

III. Fruit Fibres.—These are mostly obtained from the large, thick, and leathery covering or pericarp of the cocoanut. The bast and coir fibres of commerce, so much used for matting and for brush making of the coarser kinds, are obtained from the pericarp covering. The well-known Loopha of the shops is also a fruit; it belongs to the cucumber family, and its use as a kind of flesh brush is well known, but latterly it has also been used in the textile industries.

IV. Mineral Fibres are chiefly represented by Asbestos.

VEGETABLE FIBRES.

Physical and Chemical Properties.—The principal vegetable fibres are plumose and 'bast.' Both are used for spinning and for weaving, and their prices fluctuate in accordance with the quality and quantity of the annual crops. The plumose fibres are composed of cellulose. Each fibre is a unicellular hair or trichome. Cellulose is one of the three principal constituents of the vegetable cell. It forms the outer membrane of the cell wall. It is a somewhat inert carbohydrate, the chemical composition of which is expressed by the formula $C_6H_{10}O_5$. The cotton hairs are nearly pure cellulose; they originate in, and are attached to, the testa of the seed, the so-called fibre being a local elongated outgrowth of the cell wall. The young fibre is hardly a tube, but becomes tubular when ripe, in which are found the protoplasm and cell sap. The apex is solid. During growth the cell wall increases in thickness by the deposition of new cellulose material from the protoplasm; the latter is the vital element, and when it is withdrawn an important change takes place, the free end of the fibre twists up and assumes a spiral or convolute structure when fully ripe. The essential quality of most cottons is strength, which depends on the amount of spirality in the fibres and serves as a clue to the value and the classification of raw cottons generally. When cotton fibres are treated with Schweitzer's solution (an ammoniacal solution of oxide of copper), some important structural characters may be discerned. The late Mr. John Butterworth, F.R.M.S., of Shaw, Manchester, made some researches on cotton fibres magnified 1600 diameters and treated with the reagent. Mr. Butterworth noticed spiral threads apparently crossing and tightly bound round the fibre at irregular distances, also spiral threads passing from one stricture to another. The core of the fibre had a spiral form which, in transverse section, showed the presence of concentric rings. As to the waxy coating of cotton fibres "Mr. Butterworth stated his belief that its relative scarcity, scantiness or abundance would be found materially to affect the working capabilities of cottons; also that as long as it is present a perfect bleaching cannot be obtained" (Marsden's *Cotton Spinning*).

The bast fibres of commerce are obtained from the stems of various British and foreign plants. Bast fibres are multicellular. The cells are long and hexagonal in transverse section; they taper at both ends and overlap one another laterally, while their walls are composed of more or less thickened lignin or woody material, as in the stems of trees, and in jute (*Corchorus*).

The differentiation of these fibrous cells depends on the age of the stems, and the proximity of the fibres to the epidermis or to the middle layers of the bark in the dicotyledonous plants.

The fibro-vascular bundles of monocotyledons are closed, and independent of one another. The good commercial qualities of these fibres when separated from the ground tissue in which they are found depends upon their moderate length, strength, flexibility, and the number of fibre cells in each bundle. The bundles serve as mechanical supports for the softer parts of the plant. In the microscopic examination of these bundles certain reagents may be used, such as iodine, sulphuric acid, glycerine, carbonate of soda, carmine, and Schulze's solution (chlor. zinc iodine). The last-mentioned is a handy reagent for distinguishing cellulose, lignose and suberose tissues, as it colours cellulose blue; cork and lignified cell walls, yellow; protoplasm, brown; and starch, blue.

Aloe, American (*Agave Americana*, Amaryllidaceæ).—The parallel veined leaves yield the useful fibre known as Aloe Fibre and Pité Hemp. The fibres are separated from the leaves by bruising and steeping the latter in water and then beating them for a time. They are used in the manufacture of common cordage threads and paper. The American Aloe was introduced into England as an ornamental plant in 1640. It is stemless; the leaves are broadly sword shaped (ensiform) with spiny teeth, and the scape of the flower is branched. It was formerly thought that the American Aloe only flowered once in a hundred years, but it is now known that the flowering depends upon the situation it is grown in and the culture bestowed upon it. Sometimes the name of "Aloe" is dropped and the generic name of Agave substituted. THANK GOD.

The juice of the leaves of this plant just before flowering contains much sugar and mucilage; when fermented this yields a vinous acid beverage called Pulque, which at one time was highly esteemed by the Mexicans.

It belongs to the order *Amaryllidaceæ.* Fig. 2 is a photograph of a young plant of *Agave Americana* in my possession grown as a window plant.

The fine white fibres are sometimes used for brush-making, but are almost too delicate for commercial use.

Aloe, Bastard, or **Manila Aloe Fibre** (*Agave vivipara,* Amaryllidaceæ). —These fibres occur in the fibrous bundles that have been detached from the ground tissue of the leaves.

The plant is a native of India. Its specific name is derived from the peculiarity its seeds have of germinating before they leave the

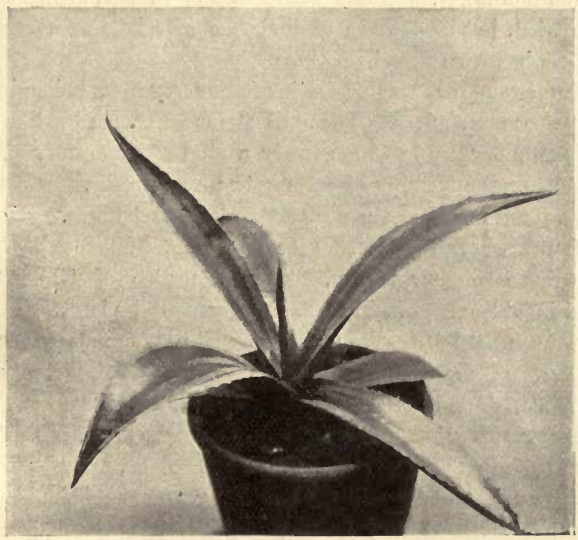

Fig. 2.— *Agave Americana* (young).

parent plant. In order to obtain the fibres the leaves are retted for fifteen or twenty days and the fibres are purified by washing and preparing them. The fibres are strong and sometimes known as "Maguey," and have been used for making violin strings, cordage rope and mats. Many other species of the genus "Agave" have furnished fibres suitable for similar purposes, including *Agave ferox Socotrina, vulgaris* and other species.

Arree or **Bun Raj** (*Bauhinia racemosa,* Leguminosæ).—A species of *Bauhinia,* known as mountain ebony.

The species are numerous; they are climbers, and mostly inhabit the East Indies; but a few come from Jamaica and the Brazils. They belong to the natural order *Leguminosæ.* The leaves are simple and bilobate, on which account (according to Loudon) Plumier named this genus of plants *Bauhinia,* after the two famous botanists John and Caspar Bauhin.

The bark of these plants is used for making rope and cordage.

Another species, *Bauhinia scandens,* has also been used for ropes, but the fibres, being hard and incohesive, are of little use, as they soon tear asunder.

Artichoke Fibre, Jerusalem (*Helianthus tuberosus,* Compositæ).—As its name implies, it produces tubers that have been used like those from the *Cynara scolymus* or artichoke. The Jerusalem artichoke is closely allied to the sunflower, and is a native of the Brazils. The stem fibres have been tried, but as yet are of little commercial importance, as only a limited use has been found for them.

Aquatic Grass or **Rush** (*Lepisonia mucronata*), belonging to the order Cyperaceæ or Sedges. The split stems of this sedge-like plant are used in large quantities in China, after a slight preparatory process, for mat-making, for the packing of tea chests, and for sails.

The plants grown near the sea produce the best fibres.

Ban Ochra or **Toja Fibres** (*Urena lobata,* Malvaceæ).—The plant belongs to the mallow family. It is a native of China, and was introduced into England in 1771 as an ornamental plant. In India the fibres have been used for sack-making as well as a substitute for flax.

The leaves of the plant are very bluntly 3-lobed, velvety on both surfaces, 7-nerved, and furnished with only one gland.

Banana, Abyssinian (*Musa ensete* (Bruce), Musaceæ).—The stem fibres have been used in the manufacture of cordage, and for some other purposes. Specimens of the fibre cleaned by means of Andrew's patent fibre cleaning machine may be seen in No. 2 Museum of the Royal Gardens, Kew.

Boombi (*Xerotes longifolia,* Juncaceæ).—An Australian plant, the leaves of which have been used for making bags.

The name *Xerotes* has reference to the aridity of the plant's habitat. It was introduced into England in 1796.

Bowstring Hemp or **Moorva Fibre** (*Sanseviera Zeylanica,* Liliaceæ). —This plant is a native of Ceylon, belonging to the endogenous "Day Lily" family. It grows in China and Japan in maritime situations, and is common in India. Fig. 3 is a photograph of the plant showing the leaves springing from a rosette at the basal end of the rhizomes; the leaves are equitant, each embracing the next younger one at the point of insertion; they grow from 1 to 2 feet long, and are plagiotropic in growth, but concave and convex on their wide surfaces.

The fibres are obtained by retting or by some simpler process. The fibres obtained from the leaves are characterised by their length, fineness, and silkiness. Mr. John R. Jackson, A.L.S., says: "Samples of this fibre have been valued in London at from £20 to £35 per ton."

As rope cordage fibres they have been held in high repute; they have also been found serviceable in the making of a good quality of paper, but the process is rather too costly. Some experiments upon Bowstring hemp were made many years ago by Dr. Forbes Watson. In a paper read before the Society of Arts, he said: "This plant grows as a weed in Madras and other parts of India. In fact it is such a nuisance that the people sometimes do not know what to do with it.

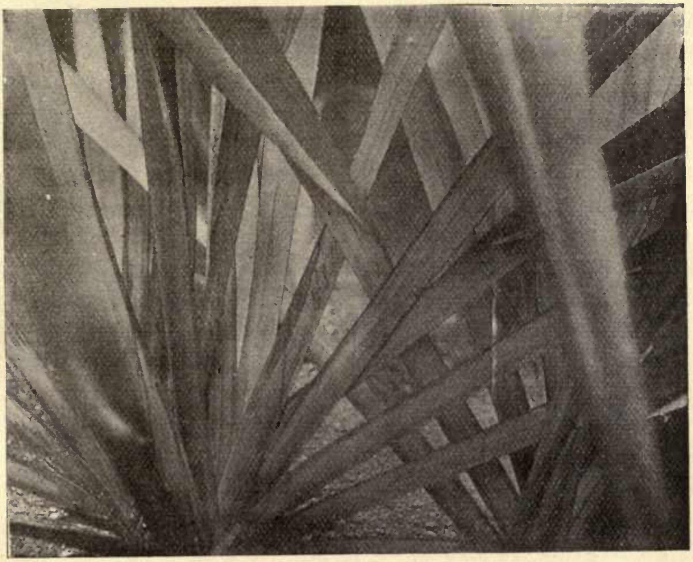

Fig. 3.—*Sanseviera Zeylanica.*

The sample which I hold in my hand was prepared upon the occasion to which I have alluded. Here is a sample which is prepared on the commercial scale in India by this machine ('Death and Ellwood's'), and I may say, with regard to that particular fibre, that it has proved that it will compete fairly with Manila hemp, which occupies a very important place in this market. Here is a sample of cord made from it, and you can all see how beautiful and white it is. This cord is made by one of the principal makers in the kingdom, and his report is that it is 7·4 (? per cent.) stronger than the best Manila, and over 4 per cent. lighter. This machine has been the means already of bringing this new and important fibre into notice, and it operates upon the plant which produces it with great facility. Then I had some large aloe leaves, some of the leaves being as thick as my arm. Here, again, is a specimen of New Zealand flax which was prepared by the machine, and here is one for which I am indebted to Mr. Christie, and which, I believe, has come from Africa. The surprising thing is the ease with which the machine operates upon all stems, leaves and stalks," etc.

A decade and a half has passed away since Dr. Forbes Watson made the above remarks; he was certainly an enthusiast, and always used his influence in the encouragement and promotion of new fibre industries. He prepared some important reports on fibres for the Government, and he superintended the machinery and material in the cotton ginning experiments at an Ancoats mill in Manchester in the seventies for the famous Lancashire spinners, who were anxious to see the cotton gins engaged in the work of separating the fibres from the seeds of cotton actually carried out.

As a result of this competition many of the third and second rate gins were superseded, and a number of good machines were concentrated in such a way that the towns of Oldham and of Bolton became celebrated for the good make of cotton gins, and to this day they have kept up their good reputation for Macarthy and Knife Roller gins.

It is sufficient to say that Dr. F. Watson's ideas were hardly realised by the trade, and at the beginning of the twentieth century we have not made much further headway, and there is still room for other trials to be made.

Broom, Spanish (*Spartium scoparium*, Leguminosæ).—The Broom plant fibres have been used for cordage purposes; according to Loudon, some of the earliest ropes were made from the fibres of *Spartium*.

The plant grows profusely in dry hilly situations, and on railway banks, where it is conspicuous for its yellow butterfly-shaped flowers.

The fibres have also been used for paper-making, but not so successfully as to warrant a strong demand for them.

The Broom plant belongs to the natural order *Leguminosæ*. Linnæus was a great admirer of its beautiful flowers.

Buaze Fibre (*Securidacea longipedunculata*, Polygalaceæ).—The plant producing this fibre is a native of Upper and Lower Guinea, the basin of the Nile and the Mozambique district. It yields two kinds of fibre, one from the bark, which is of strong texture and used for nets; the other from the stem between the layers of wood and bark.

So far back as 1857 Messrs. Pye Brothers of London gave an opinion that the fibres of Buaze were stronger than flax and much finer. Dr. Livingstone mentions that the plant was used in the Maravi country, north of the Zambesi, for making threads on which the natives string their beads, etc. The Buaze is the *Lophostylis* of some authors.

Cabbage Palm, Australian (*Livistonia Australis* or *Corypha Australis*, Palmaceæ).—The leaves of this palm are used for the plaiting material of hats; belts also have been made from the leaves.

Another species has been brought into notice, viz., *Livistonia Chinensis*; the fibres of this plant, particularly those from the fibrous sheath, have been used for making ropes. Specimens of articles, including a hat and a belt made from the *Livistonia* fibres may be seen in No. 2 Museum of the Royal Gardens, Kew.

Cat's Tail or **Reed Mace** (*Typha latifolia*, Typhaceæ).—This is a monocotyledonous plant which grows in bogs, ditches, and by the sides of brooks. The leaves are long, nearly flat, and have a bluish tint, by which the plant is readily distinguished. It is one of the most striking aquatic plants of the family *Typhaceæ*.

Fig. 4 shows the spike-like inflorescence and fruit of the Reed Mace.

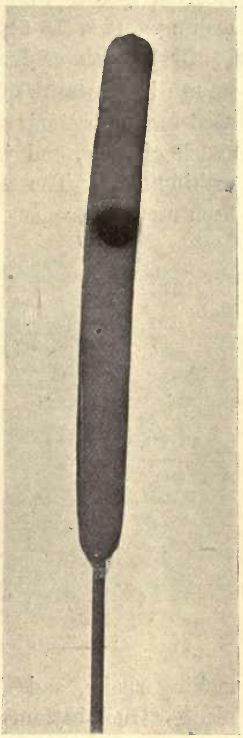

Fig. 4.—Reed mace.

The compact fertile fruit is at first greenish-brown, but later it assumes a dark brown colour and a velvety appearance.

The leaves have been used by coopers for inserting between the staves of their casks. They have also been used for making chair bottoms, thatching huts, and making baskets. The seeds are finely comose, and when ripe the down easily separates; it has been used for stuffing pillows.

Calloose Hemp is a name applied to more than one kind of fibre obtained from the Asiatic nettles, probably *Urtica tenacissima.* It is a native of Sumatra and Bungpore; its fibres are exceedingly strong, and can be converted into cordage. China grass-cloth and some other fabrics are made from the fibres of nettle stems. The plant is a nettle, not a hemp, as the name would imply.

Chagnar Fibre (*Bromelia serra*, Bromeliaceæ).—The fibres of Chagnar have been made use of by the Mataco Indians for purposes of defence. A cuirass made from the fibres is shown in No. 2 Museum of the Royal Gardens, Kew.

Mr. Jackson, keeper of the museums, speaking of the above cuirass, says: "When worn by the Mataco Indians it is padded before and behind with cotton from the fruit of the 'yachan' (*Chorisia insignis*). When the natives roll themselves in water, the fibre swells, and the cuirass becomes arrow-proof."

Chitrang (*Sterculia Wightii*, Sterculiaceæ).—Most of the species are natives of India, and one or two are peculiar to China. They are lofty trees with large leaves.

As fibre-producing plants, only the species *S. Wightii* seems to have received attention for its bast fibres, which have been used for cordage making. It is the type of the order *Sterculiaceæ.*

Club Rush or **Bulrush** (*Scirpus lacustris*, Cyperaceæ).—This rush is known in Lancashire as the chair bottom rush, owing to its having been used for the bottoms of chairs. At one time it constituted a considerable article of trade, and was much used in country districts and towns for making mats. The stalks grow from 2 to 6 or 8 feet high, and have been used by coopers for filling up spaces between the seams of casks, for which their spongy nature adapt them. It is a maritime plant, and is frequently found in marshes and ditches near the coasts. This plant is not the "Marsh Gladden," as some writers have stated. The "Marsh Gladden" is *Iris fœtidissima*, or roast beef plant, which is confined to Cornwall.

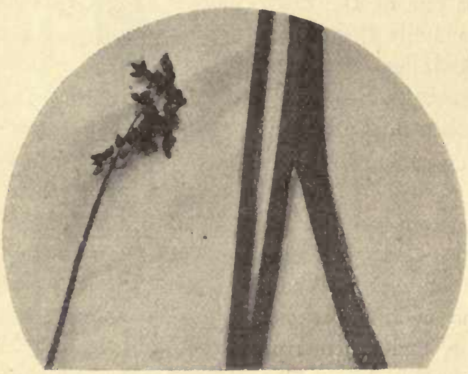

Fig. 5.—Flowers of bulrush.

The great improvements that have taken place in making chairs, and the gradual substitution of wood bottom seats in place of rush-bottomed chairs, has done much to lessen the demand that formerly existed for the use of this marine and spongy rush. There is something to be said in favour of the Bulrush bottomed chair; the seat portion was deeply inclined towards the centre on the four sides, which gave an elasticity and ease to the sitter which is certainly wanting in modern wood-bottomed chairs. The name "Bulrush" is considered by botanists to belong to this plant and not to the "Reed Mace," which is so often sketched by artists in pictorial editions of Scripture.

Fig. 5 shows the flowering stalk and the compound panicles of the heads of the Bulrush. The long part of the thickened stem is shown on the right of the illustration. The panicles of flowers when nearly mature and when in seed have a rufous brown colour, and are arranged laterally up the stalk, as shown in the illustration. The stalks grow from 2 to 6 feet high, and occasionally they reach as much as 8 or 9 feet. The plant has a glaucous hue, and is an ornament of the maritime marshes.

Coquita fibres (*Jubæa spectabilis*, Palmaceæ).—A native of Chili, South America. It is a tall palm tree with rudimentary scale-like structures at the base of the petioles.

From the back a fibre is obtained of considerable strength, which is much used for cordage purposes. Cables have been made from the bark fibres and are reputed to be more durable than hemp cables.

Cordyline (*Cordyline edulis*, Liliaceæ).—This plant belongs to the asphodel family (*Liliaceæ*). A garment formed of cordyline fibre and dyed with the bark of a species of "Fagus" or Beech is in No. 2 Museum of the Royal Gardens, Kew.

Dab (*Poa Cynosuroides*, Gramineæ).—The culms of this species of meadow grass have been used in some parts of India for making mats and ropes.

It is known commercially as "Dab" grass. Some botanists have considered it to be a species of *Eragrostis*.

Dagger Plant (*Yucca aloifolia*, Liliaceæ).—A liliaceous plant, the leaves of which have been used as material for the straw-like plaiting of bonnets. Many species of this genus are remarkable for their sword-shaped or ensiform leaves, often terminating in a horny needle-like point, hence the name of "Adam's needle" given to this genus.

Date Palm (*Phœnix dactylifera*, Palmaceæ).—The common date palm is a native of the Levant. In Barbary bags are made from its leaves. The Egyptians use the leaves as fly flaps, and as brushes for cleaning their clothes.

Fibres of the date palm have also been used for making cords, ropes, baskets, and hats.

Bentley [1] says of this plant: "The leaves, the fibres obtained from the leaf stalks, the wood, and, in fact, nearly every part of this palm is applied to some useful purpose."

Devil's Cotton or **Abrome** (*Abroma augusta*, Byttneriaceæ).—The plant is a native of the East Indies; it was introduced into England in 1770. The peculiarly white bark has yielded fine silky fibres from which cordage has been made. It has been recommended as a substitute for silk. The fibres can easily be detached by maceration. Dr. Watts says: "There are many purposes to which Jute is put nowadays, which

[1] *Manual of Botany.*

'Abroma' could meet, with greater acceptance, and which it most certainly would by this time have supplied, but for the early success of Jute." Messrs. Cross and Bevan give the length of staple as from 4 to 8 feet; but so long a staple is quite unsuited for admixture with cotton or for being spun with cotton-spinning machinery.

It might be successfully used along with other vegetable silks for upholstery or other purposes.

The fibres of young plants seem to differ in properties from those of old plants. Thus Messrs. Cross and Bevan say: "The fibre obtained from new plants has a larger percentage of cellulose, and is less readily attacked by hydrolytic agents, but microscopically the ultimate fibres are somewhat thin and ill-formed." A writer in Spon's *Encyclopædia* says: "It grows well and quickly, and yields two to four crops yearly of bark fit for peeling; three trial cuttings gave 271 lbs. of clean fibre. The bark is separated from the shoots by maceration in stagnant water for four to eight days in summer; in the cold season a three times longer steeping is necessary and greatly weakens the fibres. The latter are naturally white and clean, and require no dressing. They are about $\frac{1}{10}$th stronger than *Crotalaria juncea* (Sunn Hemp)—say 68 to 74 lbs., and are much more durable in water. It is used locally as a substitute for hemp in cordage manufacture, and is equal to jute for paper-making purposes.

Dib.—This is a species of *Scirpus* or Bulrush which grows in India. The stems are used for making mats. After the stems have been macerated and beaten to make them pliable, they are used as the woof in certain durable mats.

Dolichos Fibre (*Dolichos trilobus*, Leguminosæ).—The fibres of the above plants have been used for spinning and weaving "Grass Cloth." Another grass cloth is made from nettle fibres.

Dolichos belongs to the Pea family. Most of its twenty species grow in the East Indies, but Jamaica, China and Egypt have a few species each.

Dombeya (*Dombeya cannabina*, Byttneriaceæ).—A native of Madagascar. The bark has been used to a slight extent for cordage making.

Dunchi Hemp (*Sesbania aculeata*, Leguminosæ).—It is a native of the East Indies, and was introduced into England as an ornamental plant as far back as 1690.

The bast fibres of the stem have been used for making cord and twine under the name of "Dunchi Hemp."

Ejow Fibre, Egoo or **Gommuta** (*Arenga saccharifera*, Palmaceæ).—The "Gommuti palm," as it is called, grows to a height of 20 to 30 feet. The fibres obtained from the base of the leaves are stiff, strong and horse-hair like, and are known in commerce as Ejow fibres. Dr. Forbes Royle says: "Mr. Kyd, the celebrated shipbuilder of Calcutta, possessed a cable made of Ejow fibre which he had for four years exposed to all weathers and which raised the bow anchor of a merchant ship of 500 tons buried in the sands of Hoogly, in two previous attempts at which three Russian hempen cables had given way. Besides making strong and durable cordage, the Ejow fibre is no doubt applicable to a variety of purposes for which horse-hair and bristles are now employed."

As a plant yielding brush-making fibre it has gained a good reputation, and the same may be said of it for upholstery purposes. It is a native of the Asiatic Islands, and was introduced into England as an ornamental palm in 1830.

Flax or **Linen.**—The flax fibre of commerce is obtained from the stem of *Linum usitatissimum.* The plant is grown in some quantity in England, Ireland and Scotland, but the principal countries for its cultivation are France, Belgium, Holland, Russia, America and Canada.

The portion used in commerce is the bast tissue situated between the bark and the hard or woody tissue. The characteristic features of the fibres are their length, strength, fineness and colour. The fibres of flax vary with the tapering character of the stem, and become finer towards the apex. Their length varies from 0·157 inch to 2·598 inches and the diameter from 0·0006 inch to 0·00148 inch. The tapering character of flax fibres outwardly and the polyangular and fistulose character inwardly are well marked microscopical features of the fibres. The fibres are tenacious, thick-walled and flexible when used for spinning purposes and for linen manufacture.

The adhesion of the hard tissue to the bast fibres of flax necessitates the stems being macerated in running water to separate the bast from the cortical layer.

Chemical Characters.—By treatment with boiling alcohol, from 3·4 to 3·6 per cent. of extractive matter may be obtained from flax, a portion (about half) is deposited on cooling. This substance has the properties of a wax alcohol, and investigation shows it to be ceryl alcohol $C_{27}H_{55}OH$. There are also present small quantities of other bodies of a ketonic character. It is the presence of this wax alcohol that causes the bleaching of flax to be so difficult, as it very strongly resists the action of alkalies.

Cold alcohol extracts from flax a quantity of matter (about 1·5 per cent.), which appears to have a complex composition, containing chlorophyll and products derived therefrom, a little ceryl alcohol, and

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a large quantity of an oil having an orange green fluorescence, which is a ketone of some kind, to which body the peculiar odour of raw flax is probably due. Accompanying the cellulose there are about 25 per cent. of pectose-like bodies, easily soluble in boiling solutions of alkali of 1 to 2 per cent. concentration, to which solutions they impart a yellow colour. Nitric acid converts these pectose substances into mucic acid.

The oil is of very considerable importance in the spinning of linen thread, serving probably as a lubricant. Many attempts have been made to supersede the retting process now in use, but some, if not all these, have been failures, on account of the fact that the fibre prepared by their means has not spun well. This may probably be ascribed to the fact that they have used all the oil from the fibre, which becomes there fore deficient in lubricating properties, and the fibres have not that freedom of motion necessary to spin well; on the other hand, to eliminate these waxy and oily matters from the cloth after being woven necessitates a most elaborate bleaching process. The flax fibre is classed as a pecto-cellulose, that is, a fibre which is accompanied by a quantity of non-cellulosic bodies of a pectic or pectose character, whose main characteristics have already been pointed out. Another feature is that they give gelatinous hydrates.

It has been stated above that boiling with weak alkalies removes the pectose constituent intact. It is considered by some authorities that we must view the flax fibre as being a distinct compound of these two constituents, hence the term 'pectocellulose'; but this view does not seem to be altogether correct. Probably the pectose constituents are present as products of decomposition of the wood and bark surrounding the fibre when in the plant; or they may be even decomposition products of the cellulose itself. Further investigation on this point is needed. This should be partly chemical, partly microscopical, and made on different stages of growth.

When the true cellulose of the flax fibre has been isolated, it is found to have properties identical with those of cotton fibre; in fact, so far no reactions of a chemical nature have been found by means of which cotton and flax cellulose can be distinguished from one another. Their identity is established by their resistance to hydrolysis and oxidation, and by their containing no active CO or OH groups. Acids, alkalies and solvents react with the two celluloses in precisely the same manner. The only difference between them is a morphological one—the difference in the form of the two fibres. What has been said of the properties of the cotton fibres applies equally well to linen fibre when the impurities which it contains have been separated (*Textile Mercury*).

Botanical and Commercial Features.—The flax is typical of the natural order *Linaceæ*, the plants of which are either herbs, shrubs or trees.

The common flax, the purging flax, the perennial and the narrow leaved species (*L. angustifolium*) are all herbs.

In the common flax the leaves are alternate, linear, lanceolate, acute, entire. The flowers are arranged in racemose panicles, and the floral organs are arranged in whorls of five (pentamerous). The calyx and corolla are inserted alternately, the petals being of a blue colour and twisted in the bud; the stem grows erect up to the flowering stage, when it becomes forked or panicled, so that each branch of the flower stalk may be fully exposed to the light. Sometimes the flax is grown in quantity chiefly for the oil that is obtained from the seeds, and for the fibres that are obtained from the plant stem for commercial purposes.

Fig. 6 is a young seedling flax plant showing the primary, and the secondary or branching roots, that mechanically support the plant in the soil where it grows. Below the branching-off point, the root tapers, and above it the stem has a uniform thickness as far as the insertion of the cotyledons. This part of the stem has a thin median line formed by the fibro-vascular cylindrical bundles, which later become the xylem; while in the outer part of the cylinder a ring of phloem bast cells are developed which constitute the bulk of the flax fibre used commercially. The flax cultivator has two main objects in view—(1) the production of a seed with as much oil as possible, or (2) the maximum development of bast tissue. The seed of the flax plant is the "Linseed" of commerce; it is imported in large quantities from Russia and other countries. When the seeds have been detached they are crushed for the oil which they contain, viz., "Linseed" oil, an oil much used in the mixing of paints on account of its "drying" so quickly. The successful making of linoleum is also dependent upon the oil obtained from the seeds. The flax plant is much cultivated in India as an oil producer. In this case the fibres are either poorly developed or serve as reserve stores for the nourishment of the seeds during the latest or fructifying stage of the plant's life history.

In the selection of seeds for sowing preference should be given to those which are plump, heavy and glossy.

Culture.—The flax plant thrives best in a firm, moist, and sandy soil; when grown for its fibre only, the plant ought to be pulled or drawn out of the soil before it has attained its maturity, or when the nourishment stored up in the bast tissues has not been exhausted. The stems pulled out of the soil ought to be as uniform in length as possible. The flax plants are then "rippled," that is, the seed capsules are separated from the radial branches of the plant.

In Ireland retting is carried out by placing bundles of rippled stalks of flax, root downwards, in pits or running streams of water and covering them with sods, straw or rushes. As the fermentation proceeds bubbles of gas (marsh gas and carbon dioxide) rise to the surface of the water.

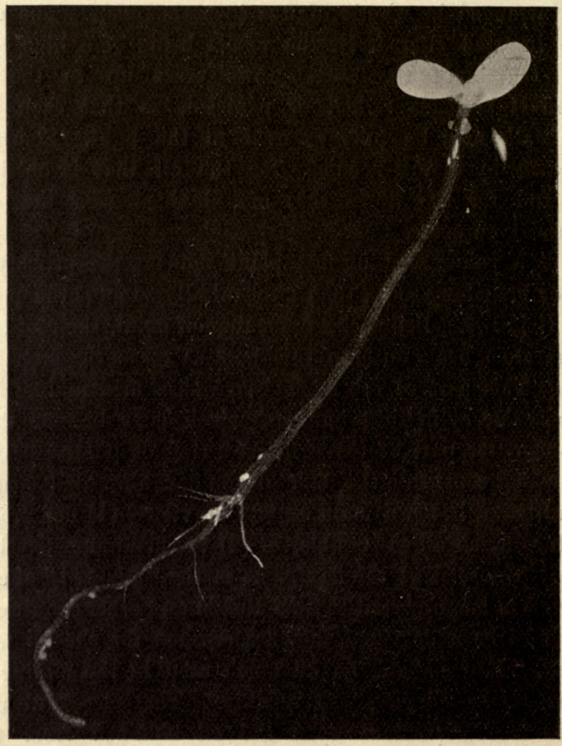

Fig. 6.—Flax seedling.

When the cortex readily separates from the cylinder, the fibres are exposed to the air and afterwards packed, or stacked, before being taken to the scutching mill.

Dew Retting.—The flax is exposed to the influences of sunlight and atmospheric conditions, whereby the fibres become brown, soft and silky.

Cotton Flax.—Flax fibres that have been steeped in a weak solution of caustic soda, boiled in a solution containing 5 per cent. of carbonate of soda, and immersed in a vat containing water acidulated with sulphuric acid, acquire the appearance of fine white silk or cotton.

Within the last four or five years attempts have been made to mix this material with cotton fibres and to spin them into a uniform composite yarn. A Lancashire firm of spinners who tried this as an experiment did not follow it up to a successful issue. The blending of the bastose and plumose fibres to make one complete yarn is not feasible to begin with. Cotton fibres are unicellular, and flax fibres are multicellular, while the structure of the two is antagonistic to their union in a combined thread.

Courtrai Flax, imported from Belgium, is remarkable for its colour,

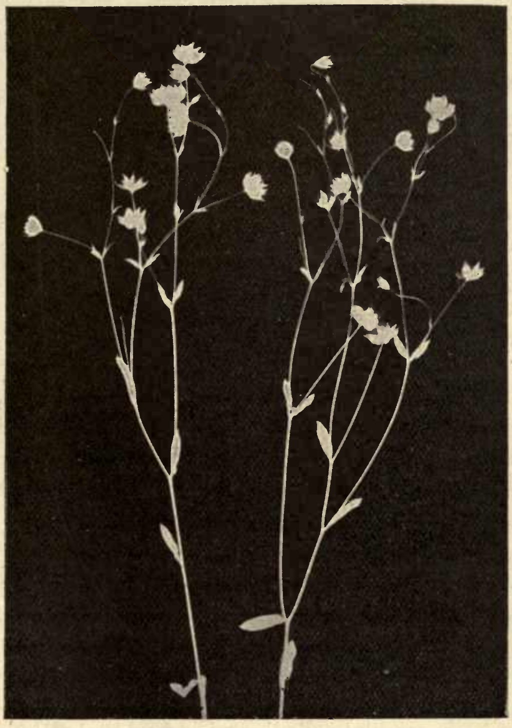

Fig. 7.—Mountain flax, *Linum catharticum.*

tenacity and fineness. When the stems have been partly retted they are put into crates and immersed in the sluggish stream of the Lys; it is of good staple before spinning. "Flax" and "codilla" are names given to the waste or broken fibres of flax during the preparatory processes of spinning. The chief processes by which flax is converted into linen are spinning and weaving.

Fig. 7 is an outline illustration of *Linum catharticum* or mountain flax, the fibres of which have been used for textile purposes. It is much shorter than the common flax and has a more definite and forked system of branching. It is common in hilly districts generally and is well known for its purgative properties.

Flax fibres were used at a very early period in Egypt, and, before cotton fibres came into notice, was probably the principal textile fibre

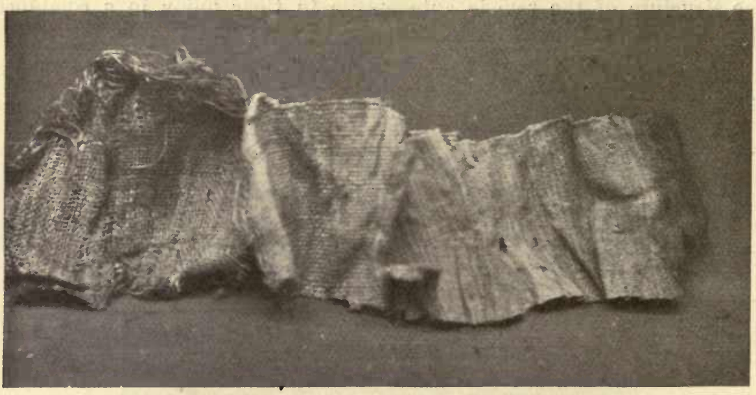

Fig. 8.—Mummy cloth made from flax.

used. Fig. 8 represents some specimens of flax mummy cloth obtained from the tombs of Egypt by Dr. Flinders Petrie, given to me by the late Thomas Roger, Esq., Egyptologist, of Manchester.

Mr. C. F. Cross, who has studied the chemical composition of the flax fibre, says: "Flax differs in essential respects from Rhea; apart from structural differences it is spun not as purified cellulose, but, chemically speaking, in its raw or natural condition. In this state it contains, associated with the cellulose, 20 to 30 per cent. of a pectic substance, a substance which is easily hydrated to gummy modifications by water and dilute alkali—being freely soluble in the latter—and also 3 to 5 per cent. of a complex of waxes and oily bodies drawn from the cuticular covering of the flax stem, with which the bast tissue is in this plant in very close contact."

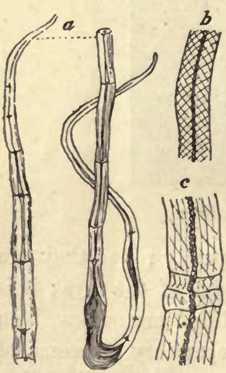

Fig. 9.—Flax fibres (magn.).

Microscopic Appearances.—Fig. 9 shows the fibres of flax highly magnified. In *a* are seen the striation and nodes which adapt the fibres for spinning into yarn and for weaving into linen cloth; *b* represents the *fibrilla* bands, as seen after the fibre has been treated with nitric acid;

and *c* is a fibre treated with nitric acid and afterwards with sulphuric acid and iodine, in which the nodes and spiral bands of fibrilla are well seen.

The classification of flax staples is given in abbreviated form, thus:—

K	indicates	Crown flax staple.
HK	,,	Light crown staple.
PK	,,	Picked crown staple.
HPK	,,	Light picked crown staple.
SPK	,,	Superior picked crown staple.
HSPK	,,	Light superior picked crown staple.

The above marks refer chiefly to Riga crown flax staples, but the lower qualities include the following commercial abbreviated terms:—

W	indicates	Wracked staple.
WP	,,	White picked wrack staple;

and several others which indicate the commercial districts of the country they are exported from and the general characteristics of each staple.

Archangel flax is dew retted, and the staples are classified under the various crowns of quality and of price.

Pernau is a Russian port from which a large quantity of flax is exported. The leading staples from this part are:—

LOD	or	Low Ordinary Dreiband (Threeband).
OD	,,	Ordinary Dreiband.
D	,,	Dreiband.
HD	,,	Light Dreiband.
R	,,	Risten.
C	,,	Cut.
M	,,	Marienburg.

The quality of the above staples are stated in their order of merit, similarly to the practice adopted for cotton, the lowest being LOD and the highest M.

In Schenck's system of flax dressing, which comprises the more recent improvements, the plants are placed in vats and kept immersed by a strong framework. Steam is admitted until the temperature of the water is raised to about 90° C. Acetous fermentation is developed, which causes the gummy cortex of the stem to be decomposed. About sixty hours' maceration is sufficient for the retting. The flax is afterwards dressed in the open air.

Goatsbeard (*Tragopogon pratensis*, Composite).—The Goatsbeard is a British composite flowering plant, with fine radiating, plumose, ciliate fibres forming a starry parachute attached to the summit of the pillars of the seeds. The plumes of fibres can readily be detached, but their rotate shape renders them unsuitable for commercial purposes.

Fig. 10 shows the peduncle, capitulum and seeds with the plumes expanded on the pillar or support ready for dispersion. The plumes might serve for stuffing purposes.

The seeds are interesting as showing a relationship to other plumose seed-bearing members, of the British flora. Goatsbeard is a biennial flowering plant.

Gebanga Palm (*Corypha Gebanga*, Bl., Palmaceæ).—This palm grows wild in Java. The leaves are much used when young for making into baskets and bags. The pith tissue furnishes a kind of sago.

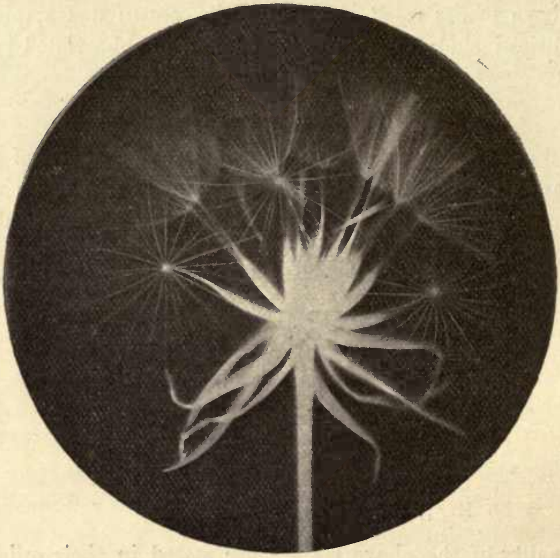

Fig. 10.—Goatsbeard; plumed seeds and stalk.

In Java it is customary to employ boys and girls to weave the leaves into baskets and bags.

Fishing nets and a kind of linen-like material are woven from the fibres. Ropes have been made from the twisted leaf stalks.

Furcrœa Fibre (*Furcrœa gigantea*, Amaryllidaceæ).—In an article in the *Textile Mercury*, August 26th, 1899, the following account of Furcrœa fibre is given, viz.: "A new commercial fibre, *Furcrœa gigantea*, is being introduced into the arts as a substitute for Manila, which it approaches closely in tensile strength. It is derived from a species of aloe recently brought under cultivation in the neighbourhood of Shenstone, Natal. The single fibres average 3 millimetres in length and 0·032 millimetre in diameter. The single cells vary between 1·3 and 6 millimetres long by 0·021 and 0·042 millimetre wide. The general microscopic appearance of the substance shows a long cylindrical fibre-like flax; iodine and sulphuric acid colour the fibre yellow. Its methyl number is 9·29, corresponding to 17·56 per cent. of lignin in the dry material, a value which is practically identical with that found in the commoner *Aloe perfoliata* (17·22 per cent.). The ash of the fibres is poor in silica (3·78 per cent of SiO_2), but very rich in lime. The average proportion of ash is 1·3 per cent.

Grass Cloth (*Urtica*).—The fibres obtained from the common stinging nettle, *Urtica dioica*, Linn., were at one time used in spinning and weaving on the continent, in the early part of the nineteenth century. The name of "Grass Cloth" is applied not only to the fabric woven from the fibres of *U. dioica*, but is associated also with the product of several species of the genus Urtica, peculiar to the floras of other countries.

Gri Gri Fibre is derived from plants of the genus *Astrocaryum* (Palmaceæ). The fibres have been used for the making of fishing nets, bow strings and other articles. The plants are natives of the Brazils; one species is known as the *A. acaule*, the stemless astrocaryon, the leaves of which have been used for the making of baskets.

Hardwickia Fibre.—The plant (one of the *Fabaceæ*) from which this fibre is obtained is a native of India, where it grows to a height of 100 feet. The bast part of the stem is the region from whence the fibre is obtained; it is of considerable importance for cordage purposes as a bastose fibre.

Hemp, Common (*Cannabis sativa*, Linn., Cannabinaceæ).—The bast fibres of hemp are similar to those of the flax plant. It is much used for sail-making, and in the weaving of other fabrics, but it is now also used extensively for rope cordage purposes.

The hemp plant thrives in a similar soil to that suitable for flax, and is a native of England. It is diœcious. It has been grown pretty extensively in the low alluvial districts of Lincolnshire, and at Holderness. Hemp fibre is largely exported from Russia and Italy.

The fibres of hemp are tenacious, and hemp cordage has been much used for window cords, but owing to their want of pliability and their tendency to suddenly snap asunder, cotton ropes have been largely substituted for them.

Fig. 11 shows a young seedling plant of hemp, with its two first leaves or cotyledons, which, in a growing state, are quite green and capable of assimilating carbon dioxide. The cotyledons, as in most plants, are only temporary structures, and fall off soon after other well-formed leaves have appeared on the stem. Above the cotyledons is that part of the stem termed the epicotyl, at the end of which is the first whorl of foliage leaves. In this case they appear to be sessile, ovate, acute at the apex, serrated at the margins, and with pinnate or feathered venation.

Fig. 12 shows a mature female hemp plant. The fruit and seeds are borne in the axils of the cauline leaves which are digitately segmented, and distinctly stalked, and are arranged decussately.

Hempen window-cord is often suddenly snapped after having been in use for some time. The strands of fibres are broken abruptly, as though chopped or cut with a sharp instrument. Each of the strands has been made up probably of similar individual yarns, then doubled together into one yarn; but with all this extra doubling, the bending of the strands is ungraceful, and considerable friction and wear takes place as a result.

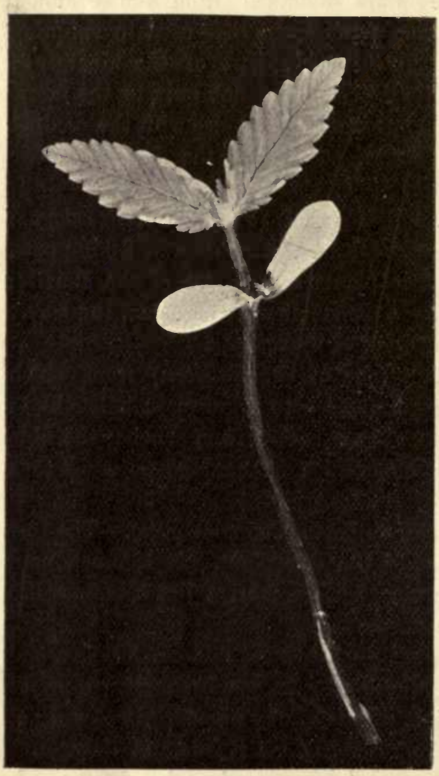

Fig. 11.—Hemp seedling.

According to M'Culloch, the principal advantage of hempen cloth over that of linen is that the colour improves in the wearing qualities in the former, while it deteriorates in the latter. It is stronger and more coarse than flax fibres. Prof. A. H. Church says: "The chief constituent of the fibre of hemp is, of course, cellulose, but small quantities of other substances are always present, the purest sorts, however, being richest in cellulose.

A fine sample of Italian hemp gave on analysis the following percentages:—water, 8·9; wax, 0·6; ash, 0·8; matters soluble in water, 3·5; lignose, albuminoids, etc., 8·4; cellulose, 77·8. An ordinary sample of Russian hemp contained no less than 10·5 per cent. of moisture and 1·5 of mineral matter, with but 72 of pure cellulose. By boiling a portion of this sample for four hours with water in a sealed tube at 150° C. a soluble extract amounting to $\frac{1}{10}$th of the original hemp was obtained, Manila hemp giving 15·4 per cent., and Phormium fibre no less than

19 per cent. when similarly treated. Dilute solutions of iodine and sulphuric acid, successfully applied, give to hemp fibres a greenish hue. The ash of hemp is rich in lime. The principal ports at which hemp is imported are Hull, Liverpool, Leith and London.

Microscopic Appearances.—Fig. 13 represents the hemp fibres as seen under a high power objective of the microscope. The fibre shows a remarkable linear structure with intermediate nodes, the one marked (*a*) shows the central structure with one distinct crossing; (*b*) represents the hemp fibre when treated with nitric acid, which shows up the fibrilla and the undulations at the bend of the fibre.

Hemp, Italian.—The fibres of Italian hemp are considered to be

Fig. 12.—Hemp plant, mature female.

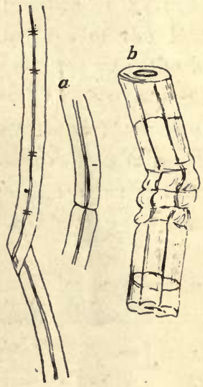

Fig. 13.—Hemp fibres (magn.).

about the best of the hemp fibres that are put upon the market, mainly on account of their graceful pliability.

On the 15th April 1899 Messrs. Ide & Christie made the following quotations on these fibres, viz.:—"Italian.—The market is quiet, the increased prices demanded by exporters, combined with the firmer markets in Italy, tending to limit business. The stocks of cordage hemps are reported to be considerably reduced, and quotations must now be reckoned on the basis of £27 for P.C. cost and freight."

In the illustration on p. 24, No. 9 in fig 14 shows the Italian hemp taken from the bale as first imported. The fibres vary in staple and length, are of a greyish colour, and are somewhat glossy.

No. 10 represents the Italian fibres after dressing or heckling; these are known in the trade as Italian Line. In this state the fibres seem finer, staple more regular, glossy and parallel.

No. 11. The Italian Tow or waste shorts, eliminated from the staple of No. 9.

No. 12. Rope spun from "Italian Line."

No. 13. Is of the softer spun yarn from the fibres of "Italian Line."

No. 14. Twine made from the yarn of "Italian Line."

No. 15. Hard twisted and level packing cord made from "Italian Line."

No. 16. Plaited cord made from fine twine spun from "Italian Line."

Fig. 14.—Hanks of Italian hemp.

Hemp, Russian.—The cultivation of hemp is largely carried on in Russia, and when the fibres have undergone the necessary preparation they are packed in bales and sent to the market.

The prices of the bales of hemp were quoted by Messrs. Ide & Christie (the well-known fibre importers) on the 15th April as follows :—Hemp, "Russian,"—Both on spot and for arrival the demand is quiet, nevertheless values are well maintained. The Russian markets hold very firm. We continue to quote Polish Winter dried O,S,F,S,P,R,H at £27 ; S,F,S,P,R,H at £27 ; FSPRH at £25, 10s. ; highly selected Riga NOFSPRH at £30, 10s. ; RMRH at £26 ; Petersburg Layer at £19 to £23, 10s. ; c,i,f, East Coast.

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In Fig. 15, No. 1 is a sample of Russian hemp taken from the bale as first imported; the fibres vary considerably in width and colour, but are very strong, and resemble at first sight newly stacked hay. No. 2 is the same Russian hemp after it has been dressed or heckled. The fibres are now more pliable, more uniform in width and general appearance, and are now designated Russian Line.

No. 3 are the waste fibres from No. 1; they vary in strength and fineness, and have a slight lucid appearance. In the trade they are known as shorts, refuse or "Russian Tow."

No. 4 shows the yarn spun from Russian Line as No. 2; its dark

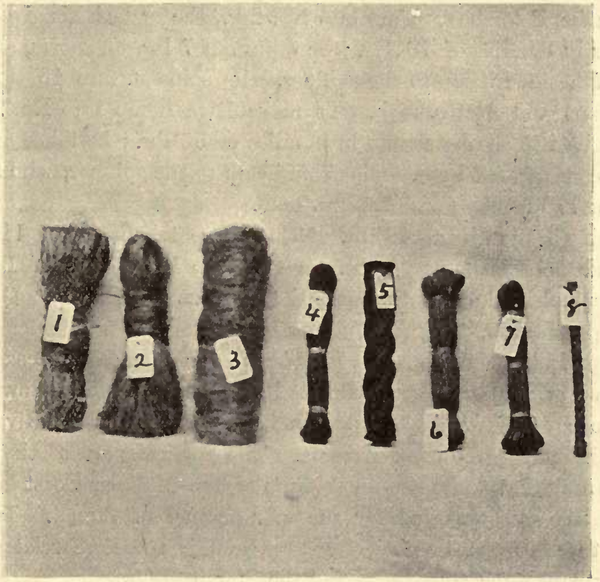

Fig. 15.—Hanks of Russian hemp.

brownish appearance is due to the tarring process it has been put through to render the yarn more durable in use.

No. 5 is a tarred yarn spun from Russian Line intended mainly for "ships' purposes"; it is well twisted, solid, with a deep marked screw line.

No. 6 is cordage yarn spun from the Russian tow fibres or shorts; it has a staring appearance and is adapted for general parcel use and some other purposes.

No. 7. Twine made from the cordage yarn shown in No. 6; it is level, round, hard and glossy, and well adapted for tying up the reeling bundles of tightly-pressed yarn in the cotton doubling trade.

No. 8. Cord made up of four strands of yarn spun from the fibres of Russian Line.

The preservation of hempen ropes has been very much studied in His Majesty's dockyards, and tarring has generally been resorted to as a preventive of decay. Some tests made by Duhamel showed that untarred ropes bore a greater weight by nearly 30 per cent. than those to which the tarring had been applied. Mr. Chapman, of His Majesty's dockyards, has given some particulars of the mode of classifying the composition and construction of ropes used there as follows: "Petersburg hemp is mostly used for cables and cablets, Italian hemp for *belt* rope and breechings, and Riga hemp for all other cordage.

To make Petersburg hemp into No. 20s., the material is given to the hatcheller in bundles of 70 lbs.; he takes out 7 lbs. of shorts, and gives 63 lbs. of heckled hemp to the spinner, who spins it into 18 threads of 170 fathoms and $3\frac{1}{2}$ lbs. each. To make Riga hemp into No. 25s., the hemp is given to the hatcheller in bundles of 56 lbs.; he takes out 5 lbs. of shorts and gives 51 lbs. of heckled hemp to the spinner, who spins 18 threads of 170 fathoms and $2\frac{8}{10}$ lbs. each.

In using Italian hemp 16 lbs. of shorts are taken out of 112 lbs. of hemp, and the remaining 96 lbs. are made up into bands of $1\frac{3}{4}$ lbs. to $3\frac{1}{2}$ lbs. each, according to the size of the yarns to be made. Quoted in art. "Rope Making," *English Cyclopædia.*

Hemp, Deccan or Kanaffe (*Hibiscus cannabinus*, Malvaceæ).—This plant has a prickly stem with palmate leaves and half sessile flowers; the latter are covered with glandulose hairs; the plant is a native of the East Indies and is known as Kanaffe. The cortical part of the stem is rich in strong fibres, and the inhabitants of the Malabar Coast have used it for cordage purposes and for the manufacture of thread. The plant belongs to the natural order Malvaceæ, and is therefore related to the "Cotton plant," the Hollyhock, and the Marsh Mallow.

Hemp, Indian Mallow (*Abutilon Avicenne*, Malvaceæ).—This also is a malvaceous plant, from which a fibre has been obtained that is reputed to be superior to Indian jute. It is used for cordage purposes, and is mixed with silk in the manufacture of the cheaper kinds of quasi silk goods.

Hop Fibres (*Humulus Lupulus*, Cannabinaceæ).—The hop is a twining plant, and the author found it growing plentifully in a wild state in the hedges about Wraysbury, near Staines, Middlesex. The stems are long, weak, and rough, and grow to a length of from 7 to 8 feet. The plant is much cultivated in Kent, Sussex, Worcester and Hants. After the hops have been picked, the stems or *bines* are cut down, often for manurial purposes. In Sweden the bines are retted, and fibres obtained from them, which are woven into a cloth of a strong and durable nature.

Jews Mallow (*Corchorus clitorius*, Tiliaceæ).—The stem fibres of this plant are obtained by retting and washing. Each bundle has numerous cells. The plant is a native of India, bears bristly leaves and yellow flowers; was introduced into England in the sixteenth century, and has been used for rope and cordage purposes.

Jute, American (*Abutilon*, Malvaceæ).—The stems of most malvaceous plants produce fibres in the bast region near the cortex or bark. The real jute plants of commerce belong to the Natural Order Tiliaceæ, the lime tree family. The American jute fibres of commerce are not produced by the jute plant, but are obtained from a plant known to botanists as the "Abutilon" or Chinese Lantern of the Natural Order Malvaceæ. This plant is grown in hothouses for its curious pendulous turbinate flowers, of which there are numerous varieties.

Jute, Common (*Corchorus capsularis*, Tiliaceæ).—The East Indian jute plant was first known to science in 1725. The plant is an annual, and has been cultivated largely for the fibres obtained from the stems. As soon as the stems are mature they are cut down, and the bast fibres are stripped from the plant and dried in a very simple way in the sun.

The fibres in a raw state are of a light brown colour, and are fine and pliable. In spinning they would be repulsive, but the harshness is taken out by immersing the raw jute in a solution of oil which renders it pliable.

Fig. 16 shows a fair sample of jute fibres in their raw state; there is much variation in the colour of the jute and jute fibres. They are made into ropes, twine of the commoner kinds, gunny-cloths and gunny-bags. The fibres are also known under the name of oakum. The old ropes of jute are cut into short lengths and sent to the Union Workhouses, where the tramps of the casual and other wards have a certain number of ounces of oakum to pick daily during their stay.

In the cotton panic of Lancashire, 1862 to 1866, tons of this material were picked in the workhouses of the cotton-spinning districts. The worst feature of jute is that, if wetted, it soon becomes weak and rotten. The fibres are several feet in length, have a satiny lustre, on account of which they are sometimes used in the manufacture of the cheaper silks.

The plant is a dicotyledon, and the fibres are developed from the bast region of the stem; hence they are regarded as stem fibres, analogous to those obtained from flax, hemp, ramie, and lime.

The yarns are used for the backing of hearthrugs, lining of ladies' slippers, canvas, collars of gentlemen's coats, and burlaps for bales of jute, or hemp coverings. A bale of jute, formerly, only weighed 300 lbs., but now its weight is often 400 lbs. India has become a famous seat of the jute industry, and is now a keen competitor with Dundee.

An alluvial formation with a hot and moist soil is the best suited for the jute plant. The sowing time is March, April and May; the time for cutting the jute plant is just when it appears in full flower; if cut at a later stage the tissues undergo some change, the fibres become hard and brittle, particularly if the plant is allowed to seed.

The jute, when cut, is retted in a manner nearly similar to the system that is adopted in the case of flax. In some cases it is stalked

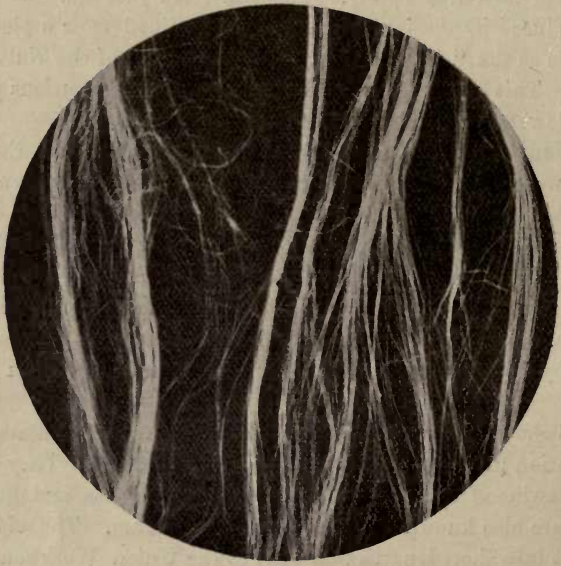

Fig. 16.—Jute fibres.

before retting. The bast fibres when detached from the stem of the plant are dried in the sun.

It is essential that jute should be packed in a dry state; otherwise, it is liable to heat and burst into flames. This is known as spontaneous combustion.

"Cuttings" are the woody ends of the jute plant, and the fibres of the lowest class are known as "rejections."

Microscopic Appearances.—Fig. 17 shows fibres of jute as seen under the microscope; it is a bast tissue with apparent bundles of stout, glossy fine cylindrical fibrils with the walls irregularly thickened. (*a*) shows the normal structure of the jute fibre, and (*b*) the fibres when treated with nitric acid under a high power objective.

According to Cross and Bevan, the substance of the jute fibre is not cellulose, but a peculiar derivative of it which has been termed "bastose."

The jute fibre readily dissolves in alkalies and mineral acids at a low temperature. Sulphuric acid and iodine turns the fibre yellow.

Kaffir Hemp (*Grewia occidentalis*, Tiliaceæ).—A native of the Cape of Good Hope. The leaves are roundish, ovate, obtuse, with toothed margins and smooth surfaces. A bast fibre has been obtained from the stem by a process of retting; the fibre is white and of considerable strength, and is known as Kaffir hemp.

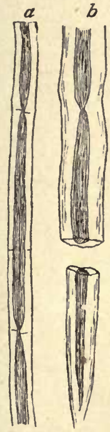

Fig. 17.—Jute fibres (magn.).

Another species, *Grewia oppositifolia*, is a native of the Himalayas; it has been used for making ropes and in the manufacture of cloth.

Karatas Fibre (*Karatas Plumieri*, Bromeliaceæ).—According to Dr. Seeman, the fibres of this plant have been used by the shoemakers of Panama under the name of pita. The plant is indigenous in Central America, Brazil, and Guiana; it belongs to the order *Bromeliaceæ*, the Pine Apple family.

Kendir Fibre (*Apocynum venetum*, Linn.; Apocynaceæ).—The plant producing the Kendir fibre is also known as Dog's Bane. It is a native of islands in the Adriatic Sea, and was introduced into England for ornamental purposes in 1690. It is only within the last few years that the plant has received attention for the commercial use of its fibres, which were brought into notice by the authorities at Kew.

Fibres obtained from the stems and branches have been used for fishing nets and ropes, also in the manufacture of Russian paper money. Another species (*A. Cannabinum*) has been utilised for twine bags, and as a substitute for hemp.

Kie Kie (*Freycinetia Banksii*).—A plant of the screw pine family (*Pandanaceæ*) from the leaves of which mats have been made.

Ko Hemp (*Pueraria Thunbergiana*, Leguminosæ).—The bast fibres of this plant have been used in India and China in the manufacture of material for summer clothing. The plant has a trailing habit resembling that of the genus Wistaria. The fibres are developed in the soft succulent stems of the plant.

Lace bark (*Lagetta lintearia*, Thymelaceæ).—This tree is a native of Jamaica. Its outer bark is smooth and light coloured, with glands on the surface and numerous lenticels. It resembles the bark of the Silver Birch. The inner cortical tissue or bast fibres are repeatedly interlaced, and resemble a lens or gauze fabric of a yellowish-white colour. It has been suggested that the bast could be used for paper-making purposes. There is little strength in the fibres if pulled asunder as a staple, but collectively, as it is detached from the tree bark, it is tough, and its texture is strong.

Fig. 18 is an example of portion of a twig showing the outer smooth,

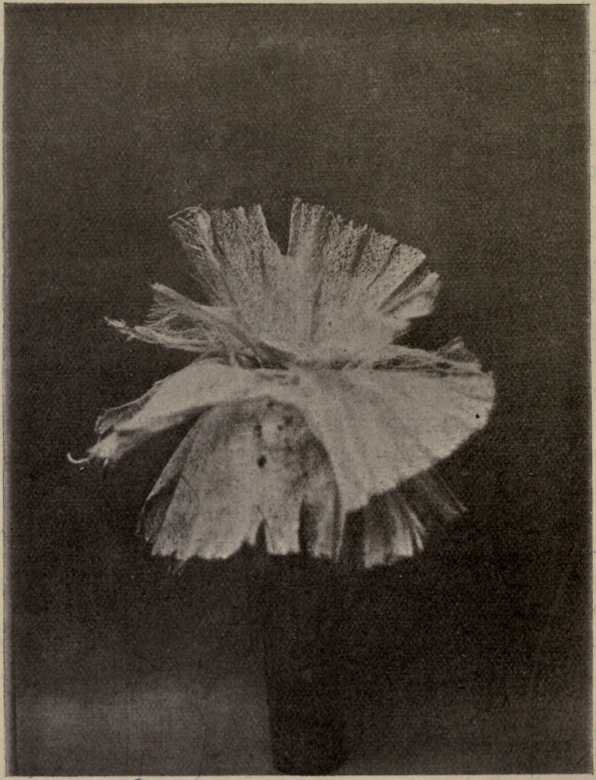

Fig. 18.—Lace bark.

glossy bark, and the lace-like interwoven fibres of the several layers of bast tissue or natural lace.

Fig. 19 is a photomicrograph of a layer of bast which has been separated from the bulk. This shows its reticulate character with the fibres finely interlaced, resembling the meshes of a fine net-like lace.

Fig. 19 shows a layer of the same bast fibres when examined under the microscope; the finer fibres are disposed across the openings or meshes, and the stouter ones form the general network.

This reticulated cortical tissue has been used for making ropes, and at one time it was employed in the West Indies for making slave whips. Sloane states that caps, ruffles, and even whole suits of clothes have been made from this peculiar tissue. Cloth made from the Lagetta has been imported at Liverpool under the name of Guano.

Lamp-wick (*Phlomis*, Labiatæ).—The hairs upon the leaves of some plants of the Labiate family are numerous and conspicuous. The use of these hairs to the plant is to prevent an excessive transpiration. The hairs and leaves obtained from *Phlomis Lychnitis*, which is a native of the south of Europe, are known as lamp-wick in Spain and are used for wicks. Other plants, whose leaves are almost quite as cottony, are

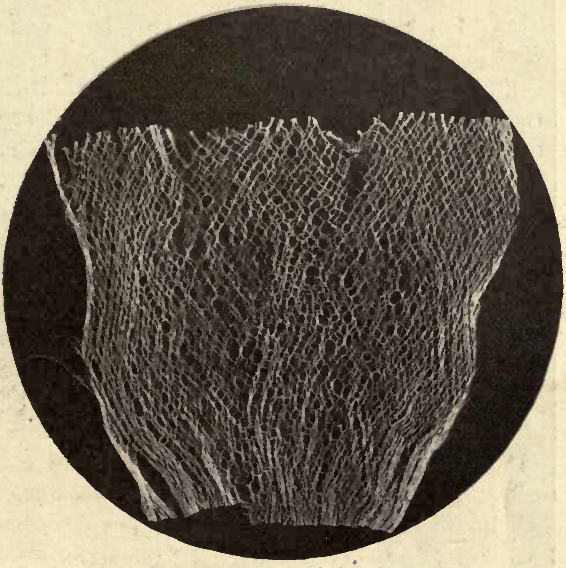

Fig. 19.—Lace bark (magn.).

known respectively as Jerusalem Sage (*Phlomis*), Lamb's Ear (*Stachys*), and the "Poor Man's Flannel" (*Verbascum Thapsus*). The latter is a member of the *Scrophulariaceæ*. These feltose-haired plants have generally opposite and decussate leaves, with floccose and downy surfaces.

Lime Tree Bast (*Tilia Europæa*, Tiliaceæ).—The lime is a large and handsome tree famous for the quantity and tenacious character of its bast fibres, which are used for various purposes. The bast tissue, or fibres, are used for cordage, pit ropes, and clothes lines, and are employed abroad for shoemaking.

The branches, when cut from the young trees, are easily divested of the bark and the bast. The latter are made into Russian mats.

The tree is extensively grown in Russia, where the cultivation and exportation of the bast is an important industry. The bast of the lime has been recommended for the manufacture of paper.

Fig. 20 shows the bast as taken from a twig of the lime tree. The layers of bast tissue are the finest when situated nearest to the

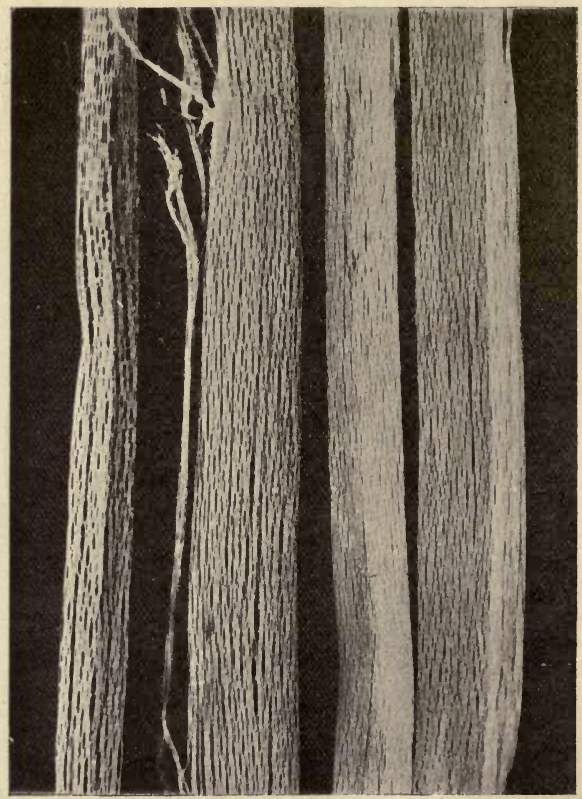

Fig. 20.—Bast of Lime tree.

region in which the bast cells are generated. This point of extension is just outside the cambium cylinder.

In the illustration the first and second rows starting from the left show the coarser bast tissue, from a position on the stem just inside the corky bark. The third and fourth are finer, and may be termed the internal bast, in contradistinction to the outer or peripheral bast and bark. The bast of most plants serves as a strengthening tissue, which is known to botanists as "Sclerenchyma."

Loopha (*Luffa fœtida*, Cucurbitaceæ).—The article of commerce known as Loopha is a fruit obtained from a species of wild cucumber. The plant has cordate leaves, and the gourd or fruit is about a foot long. In India the plant grows profusely and climbs up the palm trees. The gourd when fresh gathered has an offensive odour, hence its specific name of *fœtida*, or stinking. Botanically the name of the plant is Luffa, but in the chemists' shops it is sold as Loopha. The fruit is club-shaped, fluted in its whole length, and tapers obtusely at the end; it is made up of a several-chambered ovary.

The fine meshes of tissue of Loopha are repeatedly branched laterally and intercrossed into a fine network, which resembles a fine sieve. This structure has been hit upon as a suitable medium for filtering and humidifying purposes. In textile factories, where the rooms are heated to 80° or 100° F., it is imperative that the air should be changed often; but when cold air is admitted, or air that has been rarefied, it carries with it particles of dust. The latter settles upon the fibrous material that is being worked, and so disfigures the cops, yarn or cloth. To obviate this drawback Loopha has been used, and the cold fresh air is passed through the fine meshes of its tissue, which clears the air of dust, germs and sooty particles of which the outside air is the vehicle. This patented appliance, or Humidifier, is the work of Messrs. Hall & Kay, Engineers, of Ashton-under-Lyne, Lancashire.

The hygroscopic character of the fruit of the species *fœtida* has given rise, no doubt, to the name of sponge gourd. When the Loopha is cut up into pieces of about the size of the hand and spread out, it is laid on stout pieces of fabric and used as flesh brushes. Up to within the last few years the sponge gourd was only used as an article for the bath, and socks have been made from it.

Another kind, the *Luffa Egyptiaca*, is well known as the towel gourd, owing to the tissue of fibres being entangled together after the style of a coarse or a Turkish towel. The practical application of the moisture-absorbing properties of both species of gourds is a matter well worth consideration. The faulty construction of most of the apparatus hitherto used as "evaporators," and for the hygroscopic purification of the air of heated rooms of cotton mills, has caused impure air, though moistened, to be disseminated in hot rooms, resulting in blackened cops and damaged cloth.

If the Loopha gourd should ever become more successful, a further demand would arise, and the question would then be raised as to whether a sufficient quantity could be procured or not? This is a natural difficulty that always presents itself when any new fibre industry is taken up.

It is only doing justice to state that the authorities at Kew are always ready and willing to cultivate any plants of commercial interest, and are at all times anxious to give full information within their reach, but they cannot well become fibre brokers, though they are often consulted by expert fibre scientists.

It is very likely that the Government will some day have to provide a "depot" for the discrimination and storage of new and promising commercial fibres and similar produce.

Fig. 21 shows a photograph of Loopha as sold by chemists.

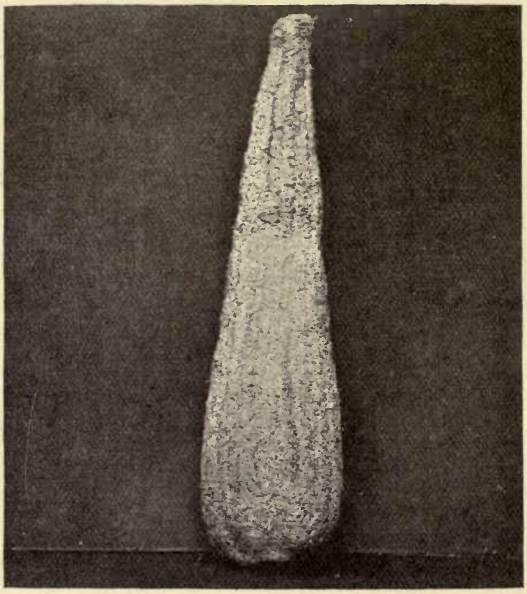

Fig. 21.—Loopha.

Fig. 22 shows a Loopha cut through longitudinally; the openings are much broader than the tissue of the exterior, thus showing how the air and water may enter freely and be retained for a time before it passes out of the finer meshes of the outside tissue. The larger openings are the cavities which were occupied by the seeds as they grew on the placentas. It is the coarse inner portion of fibrous tissue that has come into use for cleansing the skin as a flesh brush, and so successful has it been that it has competed with the small undergrown sponges of a gritty nature that are often drafted into the market for their cheapness.

Maholtine Jute Fibres (*Abutilon periplocifolium*, Malvaceæ).— These fibres are obtained from the stem of a species formerly assigned to the genus *Sida*.

The plant is a native of India; it has a shrubby habit and cordate leaves, which are downy on the underside.

The plant is remarkable for the pedicels, which are elongated and longer than the leaf stalks, and bear yellow flowers. This species was introduced into England as an ornamental plant, about 200 years ago. The distribution of the plant extends to West Africa and the Nile Valley. It has been described in the *Agricultural Record of Trinidad* by Mr. J. H. Hart, F.L.S.

The plant belongs to the Natural Order Malvaceæ, and is related to the cotton plant, but commercially it is specified as a jute.

Malachra Fibre (*Malachra capitata,* Malvaceæ). — A native of the West Indies, introduced into England in 1759; it is a malvaceous plant and yields a fibre resembling jute.

The retting process needs to be carried out soon after cutting the stems. It yields fine and silky fibres, which sometimes compete with jute. The length of the staple reaches 6 feet.

It was thought that Malachra fibre would be a very keen competitor with jute, particularly in Bombay; but so far it has not proved successful. Chemically and microscopically it has a high reputation, but commercially it has not made great headway.

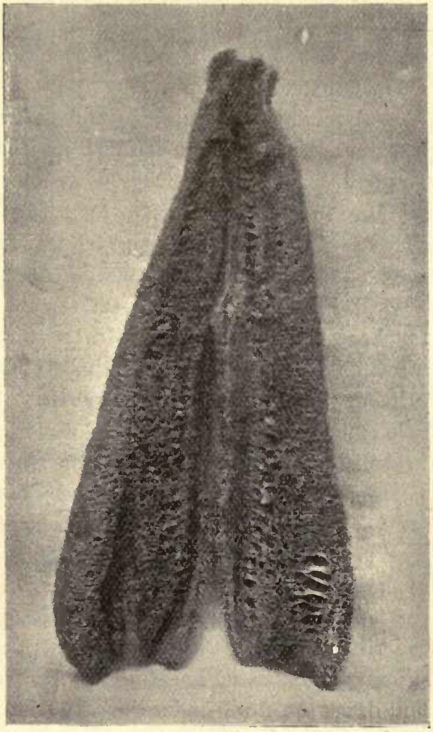

Fig. 22.—Loopha, cut through longitudinally.

Manila Hemp (*Musa textilis,* Nees, Musaceæ).—There are several species of *Musa* used for textile purposes, but the one known as *M. textilis* affords the Manila hemp of commerce; it resembles *M. paradisiaca,* but the leaves in the former are more acute, glaucous, and the stem is of a darker red colour. The plant of *Musa textilis* may be seen growing in the Palm House, Royal Gardens, Kew; the plant is indigenous to the Philippine Islands and North Borneo.

Mr W. B. Pryer, in the *Kew Bulletin* of January and February 1898, says: "Almost any land will do for the Manila hemp so long as it is not too swampy or too steep, but it thrives best on rich flat land, and does not much mind a flood so long as the water does not stop too long on the land or leave it swampy afterwards." The insertion of the leaves on the plant stem is decurrent.[1]

"A stem weighs from 20 to 80 lbs. No machine that I am acquainted with has yet been discovered that will extract it to pay. The native method is simple and cheap. The stem is cut down and each leaf-stalk detached from the others.

"After this the operator sits down with the end of a stalk in his lap; he then makes a slight incision just beneath the fibre at the end, and giving a smart twitch, brings away a strip or ribbon of the cuticle with the fibre in it from the whole length of the stalk, much in the same way that the fibrous part of a rhubarb stalk is taken off when preparing it for cooking. This operation is best performed on the plantation itself, as the discarded portions of the stem remain as manure. When a sufficient number of ribbons are obtained they are carried to a hut for treatment. The appliances used for the actual extraction of the fibre are of the most primitive and inexpensive character. A blunt knife is obtained and a hole is made in the blunt end of it, through which a string is passed, and to which a number of bricks or stones are tied. The knife is then attached to a block of softish wood; the blade of it passing on the wood, against which it is held by the weight of the tied-on stones.

"Another piece of this rope or string is tied through the same hole in the knife, running over a bit of wood above it, to a treadle worked by the foot. All is now complete. The operator twists the end of one of the ribbons round a small piece of wood so as to get a firmer hold, and slipping it under the knife, allows the blade to descend upon it. A steady pull drags the fibre underneath the knife, which holds back all the pith, weak fibre, and other useless matter. As the strain is heavy it constitutes a guarantee that all the fibre that is not broken is of proper strength, and the result is pure strong fibre. A boy can clean in a similar way the few inches of the end which was wrapped round the piece of wood, and the fibre is then hung over a pole to dry. This is soon done if it is a fine day, and the hemp is then ready for the market. These operations are quite simple, and can be performed by anyone; but some force is required to pull the fibre under the knife, and the particular muscles brought into play soon tire if the operator is new to the work. Men who have been brought up to hemp pulling can go on for hours without any discomfort. Some men claim to be able to make half a picul (66 lbs.) of hemp in

[1] Pryer.

a day; but the most I have ever seen produced by one man in a day was 37 catties (a shade less than 50 lbs.). With the fibre at $6 a picul this quantity would sell for $2·24, a high rate of pay in a country where wages are normally 30 cents. a day.

"It is needless to add that it would not be advisable to employ men on day wages to prepare Manila hemp, as so much depends upon the amount of force put into the work and consequently the quantity of hemp produced."

Mr. Pryer is engaged in agricultural enterprise in North British Borneo. The fibre of Manila hemp are considered more brittle than hemp fibre, and are much used for marine and other cordage purposes.

The fibres are obtained from the long leaves.

The plant is cultivated extensively in Manila, which is the capital town of the Philippine Islands.

Messrs. Ide & Christie, on 15th April 1899, reported on Manila hemp as follows: "We have another month to record of violent fluctuations in this staple; the extreme top and bottom mark some £6 per ton difference, quite sufficient to satisfy joy or sorrow, as the case may be, to any speculator. With good deliveries, small stocks and receipts, buoyancy prevailed, but one heavy receipt of 20,000 bales last Monday sufficed to break the market, and to-day the tone is very quiet."

		1898.	1897.	1896.	1895.	1894.
Receipts, etc., in Manila,	bales	709,000	875,000	809,000	802,000	792,000
Shipments to U.K. and Continent,	,,	368,000	404,000	407,000	494,000	336,000
,, U.S., ...	,,	306,000	408,000	290,000	274,000	402,000
Stock Manila, 31st December,	,,	97,000	169,370	200,000	160,480	195,820

Manila Cables, 10th April 1899:—

Receipts this year,	152,000 bales	against	264,000 bales	last year
Shipments to U.K.,	115,000	,,	103,000	,,
,, U.S., etc.,	111,000	,,	96,000	,,
Loading to U.K.,	...	,,	37,000	,,
,, U.S.,	11,000	,,	35,000	,,

Spot c,i,f, terms.

Prime roping,	34s. 0d.
Fair current,	30s. 0d. to 31s. 0d.
Seconds, . .	27s. 0d.
Good Brown,	25s. 0d.
Common, .	24s. 0d.
Quilot, . .	40s. 0d.
Lupis, . .	48s. 0d. to 60s. 0d.

Futures c,i,f, terms. Fair current basis.

Distant Shipment. Sellers 29s. 0d. to 30s. 0d.
Buyers. 28s 6d. to 29s. 6d.

No. 17 shows the raw Manila fibre taken from the bale as imported; the fibres have a creamy or silver grey lustre; they are fine and tapering.

No. 18 is the Manila fibres after they have been put through the heckling or dressing process; the lustre is thus increased and the fibres made more regular in staple length and contiguity.

No. 19 shows a bundle of creamy-coloured soft spun staring yarn from the dressed fibres of No. 18.

No. 20. A sample of rope of good lustre for yachting purposes.

No. 21. Twine spun from dressed Manila fibres; this yarn is fairly

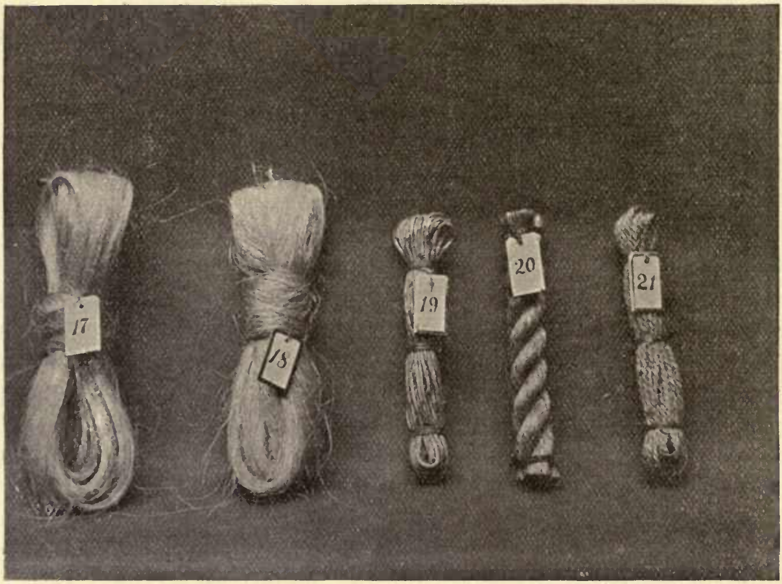

Fig. 23.—Hanks of Manila fibre.

round, with a well-marked screw line of a rather stiff straw-like lustre. It is much in demand for trawl net-making and many other purposes.

For these samples of fibres, including Italian hemp, Russian hemp, Manila and Sisal hemp, also the specimens of manufactured cords, twines and ropes, I am indebted to "The Belfast Ropework Company, Limited," Belfast, Ireland.

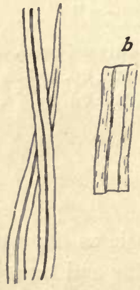

Fig. 24.—Manila hemp fibre (magn.).

Microscopic.—Fig. 24 shows fibres of Manila hemp as seen under a high power objective of the microscope. *a* exhibits the normal structure of the fibres, and *b* a fibre after treatment with nitric acid. The fibres are cylindrical, but taper toward the apex.

Mulberry Fibre (*Morus nigra*, Urticaceæ).—The bast material of the black mulberry tree, when separated from the woody portion, produces a fine fibre that almost equals silk in its lustre and elasticity.

The experiment of utilising these fibres for commercial purposes is said to have been tried in Italy. This tree is much cultivated in France and other countries for its leaves, which are used for the feeding of silkworms. The leaves are stripped off the young shoots for the purpose of sericiculture. The black mulberry is a native of India, and the white mulberry of China.

New Zealand Flax, Flax Lily (*Phormium tenax,* Liliaceæ).—A native of New Zealand, resembling an agave. It belongs to the order

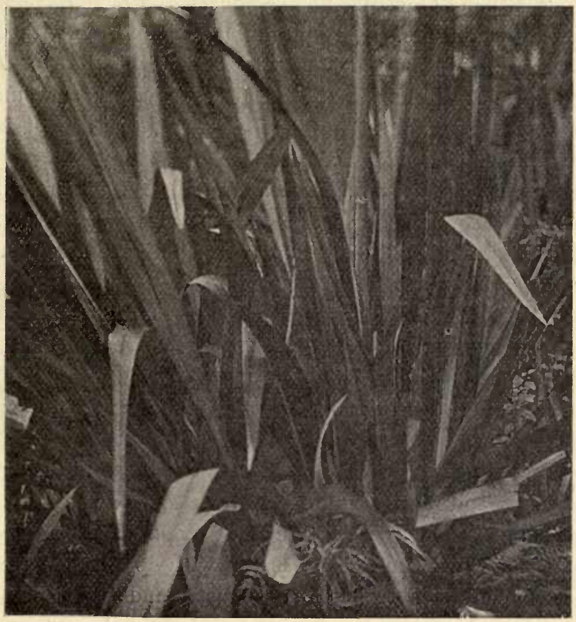

Fig. 25.—New Zealand flax (*Phormium tenax*).

Tiliaceæ. The leaves are developed in a kind of rosette, are ensiform in shape, and have an erect or equitant habit.

Fig. 25 is an illustration from a group of these plants growing in the Temperate House at Kew. The leaves are made into matting, and the fibres obtained from the leaves are used for cordage and for weaving a coarse linen-like fabric.

The fibres will bear a fair strain, but are wanting in flexibility, and, as a rule, cannot be relied upon for cross-straining effects. The characteristic features of the fibres from this plant are greatly dependent upon the kind of soil in which the plant grows. A moist soil rich in humus

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is favourable to it, and swampy ground, where the water can pass away without being stagnant, is also advantageous.

Several varieties of the plant have been brought out by cultivators, and have received local names, such as "Common Swamp," "Yellow Hill," etc.

Before a plant is fit for cutting it is essential that it should grow for five or six years. Constant cutting, however, weakens the plant. The young leaves in the central part of the rosette should be allowed to grow until they are mature.

The New Zealand Government has undertaken numerous experiments with a view to making its culture profitable, but hitherto without success. Dr Morris says: "It may be mentioned that the fibre of *Phormium* is neither a flax nor a hemp in the usual acceptation; it would be more correct to call it simply 'Phormium fibre.' It is one of the oldest exports from New Zealand."

In Phormium plantations it has been found that an acre will produce about ten tons. To such perfection has the cleaning of the fibre been carried that damasks and table cloths resembling a linen fabric have been woven from the yarn.

In the New Zealand Official Year Book for 1894, it was stated: "The greatest improvement of the present system will be effected by the cultivation and careful selection of the leaves, and by the substitution of a chemical retting process for the prolonged washing and sun bleaching which at present obtains."

The refuse fibres of Phormium have been recommended for paper-making purposes, and if an opening can be properly made in this direction, it will probably be more profitable in the end than when used as a cordage fibre, for which purpose it has met with doubtful success.

The best and finest fibre has a silky lustre and is procured from the fresh green leaves without macerations; this is done by the native New Zealanders, who use a comb for the purpose. They thus separate the fleshy portions from bundles of the leaf, in which the fibres lie parallel to each other. The soft cellular tissue in which the fibres are embedded is easily removed without leaving any hardened gummy material on their lateral surfaces. At a very early date the fibres obtained from the leaf were used for mats, twines and ropes.

Nettle Fibre (*Urtica dioica*, Urticaceæ).—This is the common nettle that grows under walls, hedge banks and about waysides generally. The stem is square. The leaves are ovate, serrate, opposite and decussate. The fibrous bundles of the stem are tough, and have been found suitable for the making of ropes. The roots when boiled with alum dyes yarn a yellow colour.

The plant when gathered is reputed to possess good purifying and cooling properties; when boiled and fried it forms the well-known nettle porridge so much partaken of in Lancashire during the disastrous cotton famine in the sixties.

The fibres of the nettle plant have lost their reputation somewhat of late years; this is probably owing to the advent of China grass fibres with thin silky lustre.

The handling of nettles is no easy matter, owing to the presence of the stings with which the square stem, the leaf stalks and the veins of the upper and lower parts of the leaves are armed.

Fig. 26 shows a vein of the leaf of the nettle with the stinging

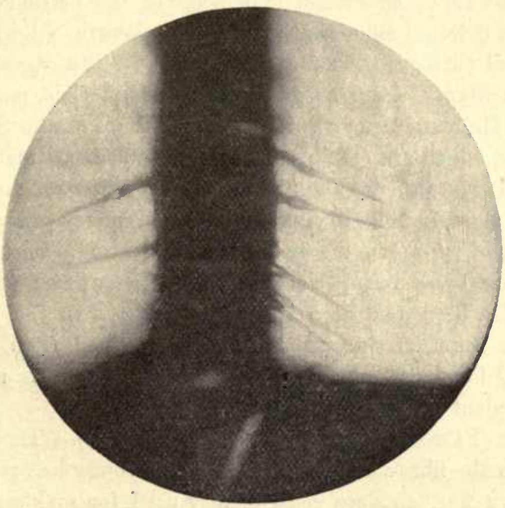

Fig. 26.—Stinging hairs of nettle (magn.).

hairs standing out prominently and the conical poison bags at the base of insertion, as seen under a high power objective of the microscope.

Neyanda Fibre (*Sanseviera Zeylanica* Liliaceæ).—This is one of the bow-string hemp plants which is indigenous to Ceylon, and is often cultivated in the hothouses of England, as an ornamental or curious sword-like leaved plant.

Mr John R. Jackson says: "The leaves are from 1 foot to 2 feet long, rounded on the back and concave or channelled on the face, and about half an inch thick. The usual mode of preparing the fibre by the natives of Ceylon and India, where the plant also grows, is either by retting or by simply beating the leaves and washing out the fibre.

"Full-grown leaves yield at the rate of 7·87 per cent. by weight of the green leaves. Owing to the smallness of the individual leaves, they are difficult to clean by machinery, but if it were possible to separate the fibre by a chemical process, the plant would probably become of great commercial value. Samples of this fibre have been valued in London at from £20 to £35 per ton."

The fibres are very soft, fine and sericeous. The plant is a monocotyledon with parallel veined, equitant, spotted leaves.

Nilgiri Nettle (*Gerardina heterophylla*, Urticaceæ).—A good fibre is obtained from the bark of this plant, but its spiny character interferes with its employment. The fibres are strong, white, glossy, and silky in their bast staple.

If a variety of this plant could be raised without the stinging weapons of defence that are so characteristic of some of the nettle group, there is no doubt that it would enhance the interest taken in Nilgiri nettle fibres for commercial purposes. The leaves are 3 to 7 lobed.

Nodh or **Myrtle** (*Myrica gale*, Myricaceæ).—This name has been given by the Highlanders of Scotland to the twigs of the Sweet Gale or Dutch Myrtle, which are employed for stuffing beds or mattresses; it is the flexuose twigs and not the fibres which are used. The Sweet Gale is a British plant found growing in bogs and mossy ground; it has a bushy habit and grows to the height of 4 feet. The serrate, lanceolate leaves are used for scenting clothes and driving away fleas and moths. They have also been used as a substitute for hops in the Highlands of Scotland. A scum resembling bees'-wax, obtained from the catkins, has been used for the tanning of calf skins. The Gale is related to the Candleberry plant of North America.

Oil Palm Fibre (*Elæis guineensis*, Palmaceæ).—These fibres are obtained from the fibro-vascular bundles of the young leaves and leaflets. They are very fine, and are consequently used for making fishing lines and for fine cords.

Much of the palm oil of commerce is obtained from the mesocarp of the fruit.

The oil is butter-like and of a rich orange yellow colour. It is very extensively used for the lubrication of the wheels of railway carriages. The plant is a native of West Africa. Palm wine or toddy is obtained from its spathes.

Okro Fibre (*Abelmoschus esculentus*, Malvaceæ).—The fibres of this plant have passed under many local names, such as Quimbombo, Gombo, Gobbo, Bandikai. The fibres are long and silky, and have been used for cordage, sacking, and paper-making.

The plant is an annual, and is largely grown in the East and West Indies. The fibres are obtained from the stems. The pods are horn-like, and are used as a table vegetable, being gathered green and either made into soups or pickled like capers. They are full of a nutritive mucilage, and when buttered and spiced, make a very rich jelly.

Ooha Fibres (*Polypodium phymatodes*, Polypodiaceæ).—The red polypody of the East Indies was introduced into England in 1823 as an exotic ornamental fern. Little has been known of its fibres, and we are indebted for our information to a report forwarded by Mr R. T. Simons, H.M. Consul in Tahiti, of the principal fibres obtainable in the Islands of the Society Group.

Ortica.—In the *Descriptive Catalogue of Useful Fibre Plants of the World*, by Mr. C. Richards Dodge, recently issued by the United States Department of Agriculture, the following note (p. 213) appears respecting *Laportea Canadensis*:—"The fibres of this species before the introduction of cotton had an application more extensive than at present in Europe, where, particularly in Germany and in more northern countries, they manufactured the cloth called ortica (German *Nesseltuch*, or nettle cloth." Probably the name "Ortica" is a corruption of the Latin name of the nettle, viz., *Urtica.*

Palmetto Leaf Fibres.—These are obtained from the leaves of the *Chamærops glabra.* The plant grows in the marshy districts of Bermuda. Various articles of utility, such as hats, bonnets, card-racks, and fans have been made from the leaves, and ropes from the fibres of this plant.

Palmetto Straw (*Amomum angustifolium*, Scitamineæ).—This plant is a native of the Island of Madagascar, and was introduced into England about the beginning of the eighteenth century. The plant is closely allied to the ginger plant. It has flowers with five abortive and one perfect stamen, and bears linear lanceolate leaves. The latter are used in the Caicos for the purpose of straw hat making, where it forms an important industry for the poorer people. The plant belongs to the Scitamineæ, the Gingerwort family.

Palmite (*Prionium palmita,* Juncaceæ).—A native of South Africa, growing in marshy situations. The leaves have been used for basket making, and the fibrous portion of the old leaves for brushes and cordage. It has also been employed in the manufacture of paper.

Pampas Grass (*Gynerium argenteum*, Gramineæ).—A native of South America. The plant is tall, with spiny serrulated leaves. It is used for ornamental or decorative purposes, especially in drawing rooms. The compound panicle of the flowers and fruit has a graceful, feathery appearance, hanging in fine filamentous tufts. As a useful, elegant, and decorative grass, it scarcely has an equal.

Panama Hats (*Carludovica palmata*, Pandanaceæ).—These are made of the young unexpanded leaves of the plant, which is a native of Peru, and was introduced into this country for ornamental purposes in 1818. It is a member of the Pandanaceæ, Screw pine family. The leaves or fronds are flabelliform, with from three to five segments, and in shape resemble a fan.

In Ecuador, South America, the finest hats are made from fibres of the unexpanded leaves called "Torquilla." It is necessary to gather the leaves while very young, and to remove the veins and ribs. The membrane is separated and reduced to shreds; it is then exposed in the sun for a few days, and after immersion in boiling water it becomes white and ultimately bleached. The straw or paga is sent to different places, and manufactured by the Indians into hats, hammocks, and cigar cases. Panama hats are made in Panama, from which industry the name has probably arisen; they are also made at Costa Rica. Baskets have been made of the petioles of the leaves, which are first dyed with colours. The name Carludovica was given to commemorate the name of Charles IV., King of Spain, and Luiza, his queen, both of whom were patrons of botany.

Parao Fibre (*Hibiscus tiliaceus*, Malvaceæ).—Of this tree Mr. R. T. Simons, H.M Consul in Tahiti (in 1895), reported as follows:—"A most useful tree, supplying the natives with timber for his boats, sidings for his dwellings, and with a very strong and valuable rope from its fibre, which are divested of their leaves, cut into lengths, tied together and soaked for a week or ten days. The outer bark is then easily stripped off, and immediately under is found the layer of fibres, which, when dried, are ready for use. The tree grows luxuriantly and in abundance in the Society Islands, but the cost of the preparation of its fibre is unknown, as that material has never been purchased for export and has so far been only used locally."

Patwa or Mohwal (*Bauhinia Vahlii*, Leguminosæ).—A climbing plant, indigenous to the Himalayas and Assam. When the plant is cut down the stems are collected and their outer bark taken off, leaving the bast fibres separated. These are then immersed in water and twisted into ropes or cordage. The plant has been used for making vegetable bridges in the Himalayas. Sir Joseph Dalton Hooker mentions this plant in his delightful *Himalayan Journals.*

Payo or **Bamboo** (**Pao Lepcha**) (*Bambusa arundinacea*, Gramineæ).—Of this plant Sir J. D. Hooker, in his *Himalayan Journals*, says: "At about 4000 feet the great bamboo ('Pao Lepcha') abounds. It flowers every year, which is not the case with all others of this genus, most of which flower profusely over large tracts of country once in a great many years, and then die away, their place being supplied by seedlings which grow with immense rapidity. This well-known fact is not due, as some suppose, to the life of the species being of such a duration, but to favourable circumstances in the season.

"The Pao attains a height of 40 to 60 feet, and the culms average in thickness the human thigh. It is used for large water vessels, and its leaves form admirable thatch, in universal use for European houses at Darjeeling. Besides this, the Lepchas are acquainted with nearly a dozen kinds of bamboo; these occur at various elevations below 12,000 feet, forming even in the pine woods, and above their zone, in the skirts of the rhododendron shrub, a small and sometimes almost impervious jungle. In an economical point of view, they may be classed as those which split readily and those which do not. The young shoots of several are eaten, and the seeds of one are made into a fermented drink, and into bread in times of scarcity; but it would take many pages to describe the numerous purposes to which the various species are put."

The genus *Bambusa* and some allied genera include a number of species from India, China, and Africa, used for making ornaments, baskets, pipe stems, hats and walking sticks.

Petanelle.—This is a fabricated material composed of specially prepared peat fibres incorporated with wool fibres. The fibrous peat gives the cloth certain antiseptic properties, and the woollen fibres serve as an elastic wool clothing possessing certain prophylactic properties. Petanelle is typical of the animal and vegetable fibres. It is made into various articles of clothing, such as shirts, cycling and golf hose, also dressing gowns. For woven examples of Petanelle I am indebted to "Pate, Burke & Co.," Wool Exchange, London.

Pine Apple Fibres (*Ananassa sativa* or *Bromelia Ananassa*, Bromeliaceæ).—The fibres obtained from the leaves of this plant are fine and silky, and have been used for cordage making and for mixing with cotton fibres, and as a substitute for silk. "Pine Cloth," a durable fabric, is produced from it. This cloth is reputed to possess the property of being impervious to water. The breaking strain of some pine apple fibres has reached 150 lbs.

The plant is grown in the hothouses of the Royal Gardens, Kew. The leaves are long, sheathing at base, linear in form, with variegated, spinose, horny margins. The fibres are arranged in the longitudinal direction of the parallel veined leaves and are long, fine and lustrous.

The plant is chiefly grown for its delicious and luscious fruit. It is a native of South America, and is cultivated extensively in the Bahamas, Fiji and Natal, as also in the fruit- and hot-houses of England.

Pinguin Fibre (*Bromelia pinguin*, L., Bromeliaceæ).—A native of the

West Indies, where it grows plentifully. The fibres prepared from this plant are weak and of little commercial value. It is a very old plant, and was introduced into England in 1690 from the West Indies. Evidently it was thought at one time that it might rank as a fibre-producing plant.

Piripiri Fibre (*Pipturus argenteus*, Urticaceæ).—This is a fibre mentioned by Mr R. T. Simons, H.M. Consul in Tahiti, who, when referring to it, says: "Pipturus is a species of nettle like 'ramie,' and contains a fibre of better quality than the 'Parao,' but it is more difficult to obtain, as the plant is less plentiful in these regions. The processes employed in the extraction of its fibre is similar to that of Parao, and the cost of production is unknown, as the material has never been purchased for export and has so far been only used locally."

Poplar Down (*Populus*, Salicaceæ).—This downy material is produced on the female catkins of the *Populus macrophyllus* or the Ontario poplar, and some other species. The down has a snowy-white colour, and can be seen at a considerable distance. Its pure whiteness gives it a resemblance to cotton fibres, for which it has been mistaken by townspeople in their country walks. The downy fibres are soon blown away when the seeds are ripe. This down was used by Scheffer for the making of paper. It could be employed for stuffing purposes in some cases.

Purumu Fibre (*Sida carpinifolia*, Malvaceæ).—From the stems of this plant a fine fibre of a silky staple has been obtained, but so far it has not come into general use. The plant is a native of the Canary Islands, and was introduced into England as an ornamental plant in 1774. Its leaves are ovate, oblong, doubly serrate, resembling those of the Hornbeam, hence its specific name *carpinifolia.* It is related to the cotton plant, and placed by botanists in the Mallow family.

Puya Fibre (*Manotia puya*).—The fibres obtained from the stems of this plant have been mentioned by Mr George Watts, Professor of Botany at the Calcutta University. He says: "It possesses very few of the difficulties so hard to overcome in Rhea, and men who have experimented with it have pronounced it far more easy to deal with than the true Rhea. It is a wild plant in India, and could be produced in any quantity.

Rajmahal Hemp (*Marsdenia tenacissima*, Asclepiadaceæ). — This is an Indian climbing plant, the stem of which yields a good strong fibre of silky lustre, used for making bowstrings, fine ropes, twine, and for other purposes. The plant belongs to the Asclepiadaceæ or Swallow-wort family.

Rameta Bast (*Lasiosiphon speciosus*).—A tree indigenous to the

Deccan, and noted for its strong stem fibres; used for cordage and other purposes.

Ramie, China Grass, Karamushi, Rhea (*Boehmeria nivea*, Urticaceæ). —The China grass is obtained from the shrubby stems of *Boehmeria nivea*; the plant, which is quite hardy, has been grown in the South of England. Large bushy clumps of it can be seen in the Arboretum of the Royal Gardens, Kew.

Fig. 27 is a photograph taken from one of these clumps. The stems are round, roughened, and dark brown in colour. The leaves are opposite and decussate, and stalked; in form heart-shaped with broadly decided

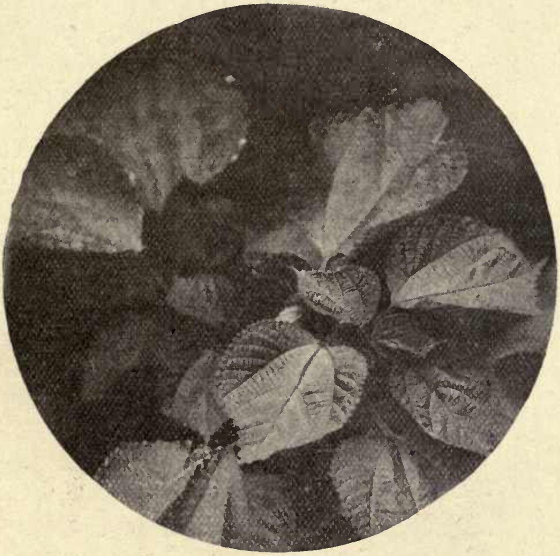

Fig. 27.—Ramie or China grass (*Boehmeria nivea*).

points (cuspidate), serrate margins and feathered venation. The ventral surface of the leaf is of a dull green, and the dorsal surface is white with feltose hairs.

The plant is indigenous in China, Japan, Java and the Philippine Islands.

Fig. 28 is an example of the ovate, cuspidate, serrate leaf with feathered venation.

Fig. 29 is an illustration of the ramie or rhea plant, *Boehmeria nivea*, var. *tenacissima*, which is a native of tropical countries.

The illustration is from a plant in the Economic House of the Royal Gardens, Kew; the leaves are opposite and decussate, ovate, acute, with a serrated margin; the normal colour of the leaves is light green. In the illustration (fig. 29) the lower leaves are normal in appearance but the upper portion of the stem and leaves stand out in strong contrast to them on account of their being variegated. Normally the leaves are green on both sides.

The two plants producing the China grass and the ramie or rhea fibres are fairly well-marked and distinct species of the genus *Boehmeria.*

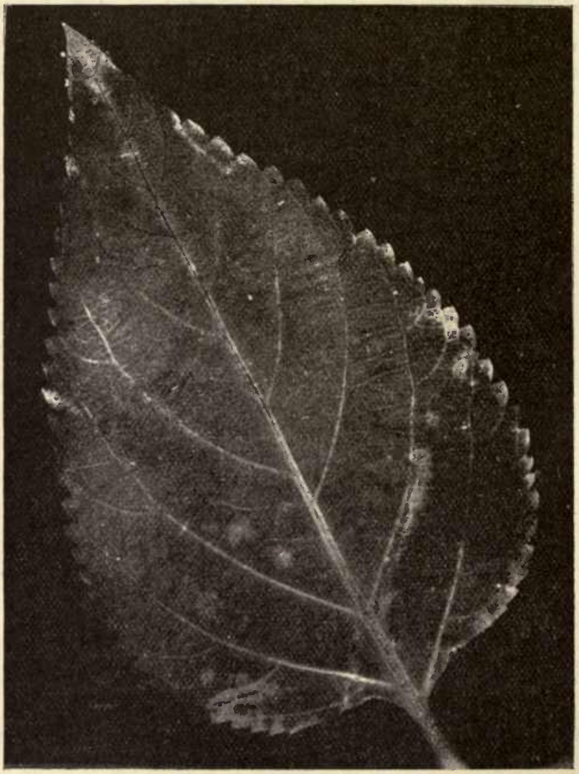

Fig. 28.—Leaf of ramie.

Commercially the terms China grass and ramie are synonymous, but the latter term will probably take the lead in the near future, and the term "ramie" herein used will be applicable to both.

There are many ramie manufacturing concerns in the counties of Lancashire, Yorkshire, Cheshire, and Derbyshire, which seem to be quietly making headway.

If the ramie industry is to become a success, and the material is to compete with either silk or the finest flax fibres, the plants must be cultivated to better advantage, so that constant supplies may be available, and that fibres of various growths, kinds, and grades may be ready for the spinner to select from.

The cultivation of the ramie plant has been encouraged by the Indian Government, and the governments of other countries ought to follow in the same direction. It is of little use sending the stems to England to be cleaned by machinery, except in cases of experiment; its cultivation should be fostered in the countries most suitable to its growth. It is essential, too, that the preparation and splitting of

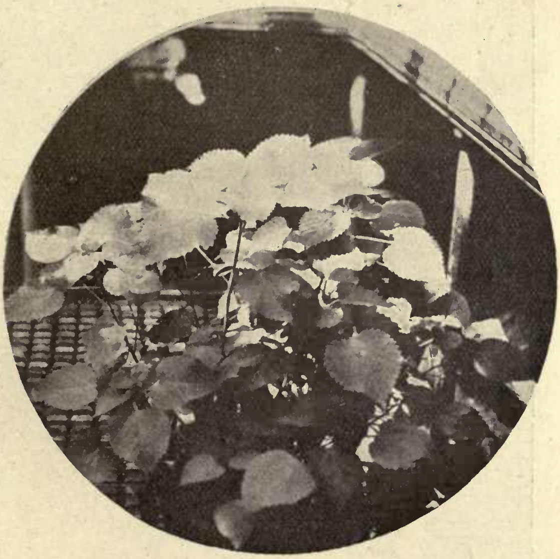

Fig. 29.—Ramie plant (*Boehmeria nivea*, var. *tenacissima*).

the stems by mechanical methods, and the cleaning and degumming of the cortical and bast tissues of the stem, should also be done in the country or district where the plant is endemic.

The culture of the plant ought to be carried out exactly after the manner of that of the cotton plants, with due regard to the development of the stem and phloem structures, for which object the cutting or pruning of the plant at the most convenient time is of great importance.

The ramie strings of fibres as imported to this country for the spinner or manufacturer are often defective.

Fig. 30 shows some of these fibres adhering closely to one another. When they arrive in this state they have a dull brownish hue, and a roughness and opacity which indicates that fibres have been allowed to continue to adhere together instead of having been separated. When ramie shows this adhesiveness, it is regarded by the purchaser as a bad sign, that it has not been well cleaned, that there has been some carelessness in its preparation, some of the outer cortex fibres having been incorporated, and imported with those of the best basts.

Fig. 31 are the filasse fibres showing a whiteness and transparency which is characteristic of the best kind imported; they have less tendency to adhere together, and separate fibres are uniform in fineness, silkiness and glossiness.

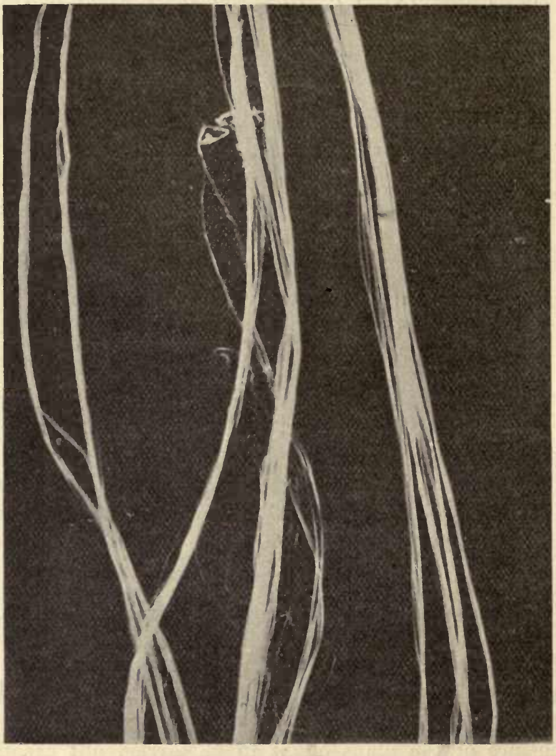

Fig. 30.—Ramie fibres.

Fig. 32 shows the parallel filasse fibres after a further stage of cleaning; they have less cohesion, as also a more silky lustre and greater flexibility.

Fig. 33 shows a still further stage of filasse fibres in which they lie in close contiguity, one to another, and resemble the finest of combed fibres met with in cotton carding and combing, excepting that the individual fibres are stouter, longer, and more silky in lustre. They have a graceful behaviour in bending, which catches the eye and infers a pliability in ramie fibre that is almost peculiar to it, and causes it to be regarded as able to compete with those of flax or of silk.

Fig. 34 represents slivers of ramie, and fig. 35, when seen highly magnified. They are flattened and tapering, with transverse markings and faint longitudinal striations; the flattened character renders the fibres more glossy. For these specimens of ramie fibres I am indebted to The Ramie Fibre Syndicate Limited, Staines, Middlesex, London.

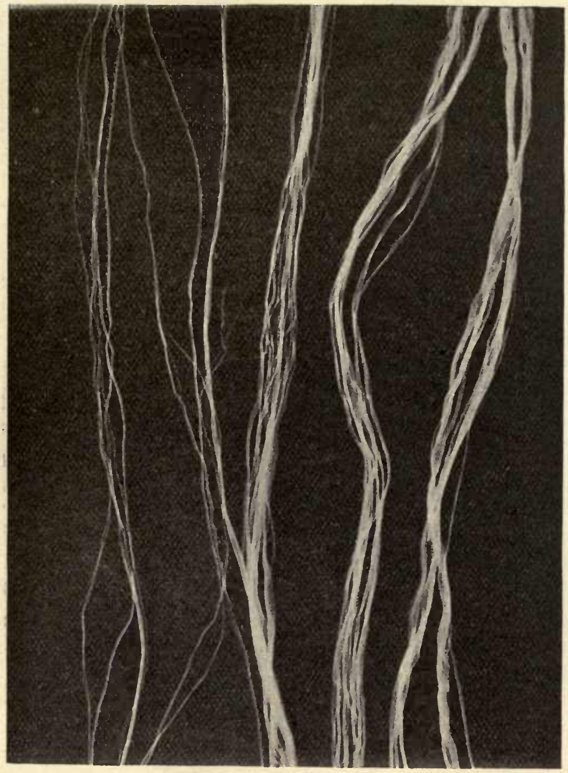

Fig. 31.—Filasse fibres.

The Ramie Syndicate may be complimented on the energy they have shown in starting so important an industry in this district, which I had the pleasure of visiting in August 1898. I regret to say that the ramie industry has not found a firm footing in England yet. Many well-known spinners and manufacturers near Manchester tried it when the fibres were imperfectly cleaned, but the Long Eaton Manufacturing Company, near Derby, and the Ramie Fibre Syndicate at (Wraysbury)

Staines, Middlesex, are perhaps at present the principal firms who are carrying on the ramie manufacture.

In Austria, France, Germany, Switzerland, and America attempts have been made, with a fair amount of success.

For the introduction of this fibre we are indebted to a Swiss botanist named Benito Boeze, who brought a few specimens from the Island of Java and drew attention to them in the latter part of the sixties.

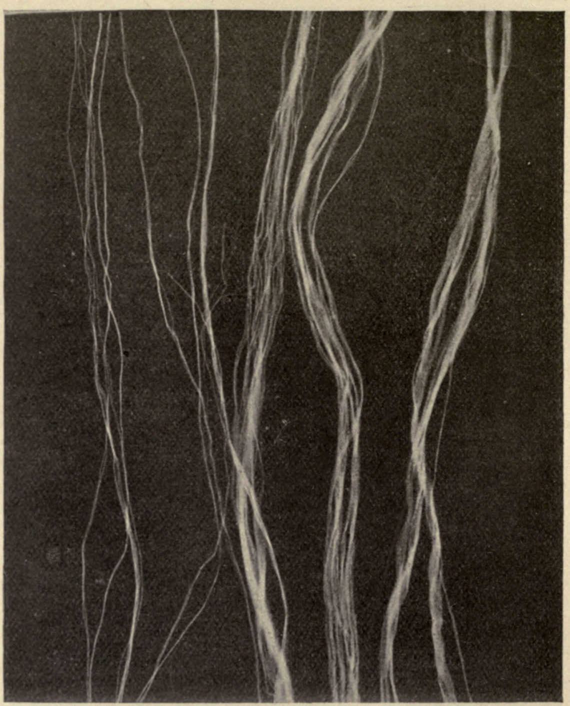

Fig. 32.—Filasse fibres.

The local name of the plant varies in different countries. In England it has been known under three names, viz., Ramie, China Grass and Rhea. In Mexico the plant is known as "Ortiga." In China TCHONNIA, and in Japan "Osjo."

The length of the fibre varies from ·088 of a yard to 2·10 yards. This variation in length of the fibre has been attributed to the favourable or unfavourable latitude the plant has been grown in. Generally speaking it can be cultivated most successfully in from 15 to 42 degrees latitude.

In the plant's growth there is necessarily a difference in the length of its internodes, the shortest being towards the apex or growing point, and the longest in the intermediate part of the stems; this must be instrumental in varying the length of the bastose or filasse fibres of the cortical region of the plant.

As a perennial plant it contrasts with the flax and hemp plants, which only last for a single season, being hence termed annuals.

The epidermis of *Boehmeria nivea* stem is hardly suitable to be mixed with the true bast fibres on account of its brown colour and roughened surface.

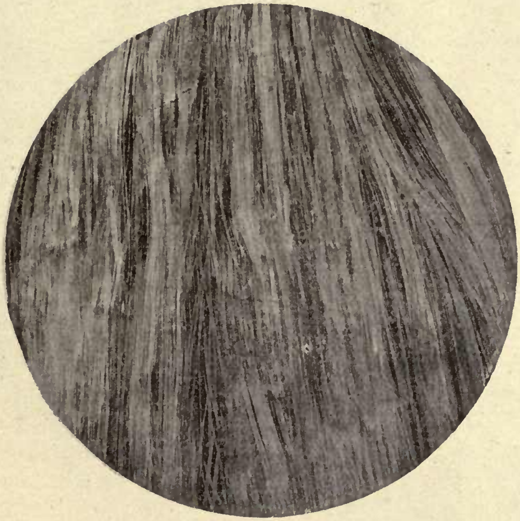

Fig. 33.—Filasse fibres (combed).

Karamushi Fibres.—General Gowey, the U.S. Consul in Japan, recently sent a communication on the Karamushi fibre from Yokohama, from which the following notes are quoted:—"The distinctions between the two (Ramie and Karamushi) is that ramie as compared with karamushi is a little stronger, the leaves larger, and both sides of the leaves green in colour, while the lower surface of the leaves of karamushi (China grass) is white. In this country karamushi only is cultivated, there being no ramie. The most important place for the cultivation of the karamushi is Yamagata Ken; next in importance are Aizer, in Fukushima Ken, Niigata-Ken, and Nara Ken. In the district of North-east and Central Japan, Kiushu and Shikoku, karamushi frequently grows wild at the base of mountains."

Manufacture.—The process of preparing the commercial product from the fibre is as follows:—After harvesting, the stalks are soaked in running water from five to ten hours. The bark is then stripped off and again soaked in water two or three hours. It is then taken out and laid on a wooden table, made of four sections of thin board 5 inches wide, 1½ feet long, and about ⅓ inch thick, and the outer (flax) surface scraped off with a thin iron scraper 4 inches long by 3 inches wide, with a handle of wood. It is again put in water, and afterwards hung in the sun on poles for four or five days. The amount of harvest is usually

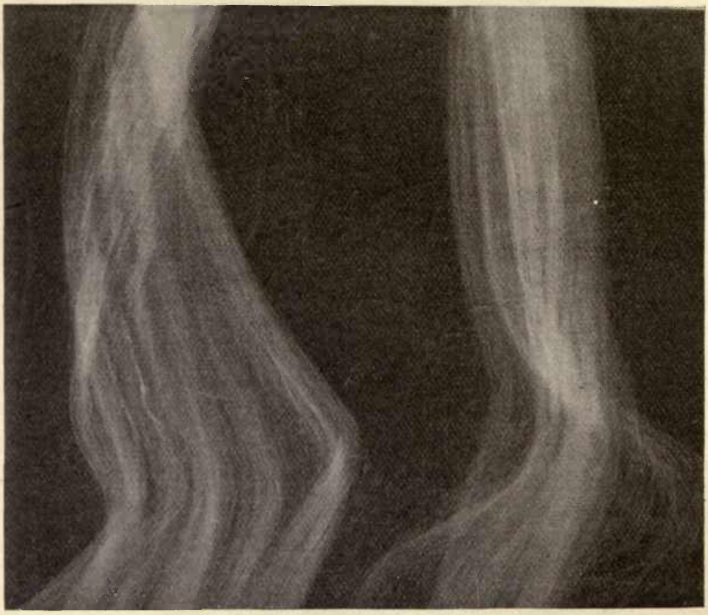

Fig. 34.—Filasse fibres (slivers).

from 50 to 60 lbs. of the commercial product and 30 to 40 lbs. of raw material to ¼ acre. The market price is from 3·50 to 4 yen ($1·75 to $2) per lb. of the commercial product.

Uses.—The refined product is largely used in the manufacture of Echigo chizimi (a corrugated cloth). The raw material is used for hemp-cloth, and when beaten out soft is used for wadding in clothing and coverlets.

Imports.—Of the so-called Chinese hemp imported into this country, the karamushi seems to form the larger part; but it is not suitable for the manufacture of fine (closely woven) fabrics like the native Yamagata product, but rather for the manufacture of ships' cables and ropes and the meshes of mosquito netting. The price of the imported article is comparatively cheap, being only about 15 to 17 yen ($7·50 to $8·50) per 120 lbs., while Japanese hemp is worth six or seven times, and the native karamushi five or six times that much. Notwithstanding its greater quality, it is being imported into Japan in larger quantities year by year, as is shown by the following table :—

IMPORTS.

Year.	Weight.	Value. Yen.	Value. United States currency.
1892	1,461,536 Kin [1]	122,431	$61,215·50
1893	2,397,355	185,061	92,530·50
1894	3,140,934	276,711	138,355·50
1895	5,141,277	359,664	179,832·00
1896	4,155,148	376,275	188,137·50

[1] Kin = 1·33⅓ lb.

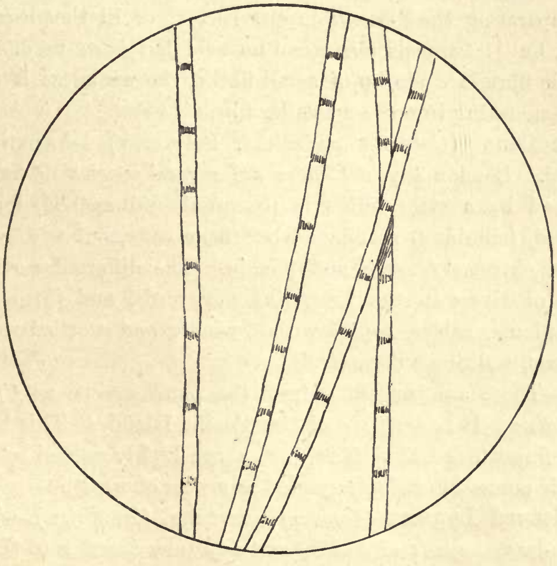

Fig. 35.—Ramie fibres (magn.).

There is no prospect of export of the native karamushi.

The various names used to represent the Ramie, Rhea, and China grass will have to be reduced some day so that commercial men will at once know what plant the fibre is produced from ; indeed the names given in different countries are a source of confusion, and it rests with Chambers of Commerce to remove this chaos.

Commercial Factors.—The ramie fibre when handled has a soft silky feel, but in pulling a staple this becomes reduced and gives way to harshness when the length of staple is drawn out. The pulling of the staple does not show that close resistance of the fibres that is met with in cotton staples. In the cotton fibres the actual resistance comes from the close contiguity and spiral character of the fibres, and depends upon their ripeness; but the drawing of a staple of ramie between the fingers and thumbs shows little resistance due to the contiguity of the fibres to one another. In the staple bulk, again, they do not lie so close together as do those of cotton fibres. This slapeiness may be put down to the want of spiral character in the fibres. What resistance there is in the staple of ramie comes from the length of the fibres as they are drawn out from their entanglements, and the nearly glabrous surface of the fibres.

In Rhea or Ramie fibre it has been found in practical working that the fibres break up and become short, hence it yields a weak fibre in commercial usage. In many cases this has been ascribed to the use of acids in separating the fibres from the cortex, or in the degumming of the tissues, but it happens also when no acid has been used. Probably as the ramie fibre is made up of small fibrils, the weakness is due to the long fibre separating into these smaller fibrils.

Rattan Cane (*Calamus rudentum*, Palmaceæ).—A native of the East Indies. Loudon says: "There are several species or varieties, all distinguished by a stem which is perennial, unbranched, long, round, solid jointed, (climbing) scandent when near trees, but without prickles or tendrils, extremely tough and pliable. The different sorts grow on the banks of rivers in the East, like our reeds, and furnish valuable props for plants, cables, ropes, withes, wicker and wattled work, hoops for petticoats, walking sticks, etc."

Rere.—These are bast fibres from the plant known as *Cypholophus macrocephalus.* It is a native of the Pacific Islands. This bast fibre is made into fine white mats. These mats are highly valued by the native chiefs, their possession being regarded as a sign of wealth.

Rush-leaved Lygeum (*Lygeum spartium*, Gramineæ).—This plant is the rush-leaved grass of Spain, and was introduced into this country for ornamental purposes in 1776.

The name *Lygeum* signifies *a bend*, in allusion to its flexible texture. Loudon says: "This plant is used in Spain, Provence, and other places, for making ropes, baskets, nets, and for filling their palliasses, or lower mattresses. Ropes were made of it by the Romans. Esparto (*spartium*) is the Spanish appellation of this and others grasses used for similar purposes."

Rozelle Hemp (*Hibiscus Sabdariffa*, Malvaceæ).—These fibres are noted for a strong texture and a silky lustre. They are also known as Red Sorelle or Rozelle hemp. The term hemp is really a misnomer in science, but in commerce is found to be convient. Like other people, those who follow commercial industries naturally have a preference for names that are readily appreciated by the buyer or seller of commercial commodities. This commercial christening does not disparage the scientific names adopted by botanists.

Sack Tree (*Antiaris saccidora*, Artocarpaceæ).—A plant of the bread fruit tree family, the trunk of which has a height of 90 to 100 feet. The fibrous inner bark of the tree is used as sacking, matting, and also for paper-making.

A writer in Spon's *Encyclopædia* says: "Trees 9 to 12 inches thick are subjected to a severe beating with a stone or club till the parenchyma or outer bark is removed. The fibrous inner bark is then stripped off in sheets, the tree being often cut into sections, yielding ready-made sacks. The sacks are filled with sand and dried in the sun; they are kept hung in smoke when not in use, and last 10 to 12 years."

The tree is a native of Malabar, Ceylon, etc.

Sennegræs (*Carex æsicaria*, Cyperaceæ).—The term Sennegræs is a name given by Dr. Nansen in his *Farthest North* to a Sedge he found. It was very useful in his travels. The plant is not British, and its nativity is not very clear. Dr. Nansen found it necessary to wear firm shoes made of the hind legs of the Reindeer buck. He says: "They are warm and strong, are always flexible, and very easy to put on and take off. They require careful management, however, if they are not to be spoiled at the outset, and one must try as well as one can to dry them when asleep at night. If it be sunny and good drying weather outside, the best plan is to hang them upon a couple of snowshoe staffs, or something of the kind, in the wind outside the tent, preferably turned inside out, so that the skin itself can dry quickly. If one does not take this precaution, the hair will soon begin to fall out. In severe cold, such as we had on the first part of the journey, it was impossible to dry them in this way, and our only resource was then to dry them on the feet at night, after having carefully brushed and scraped them free from snow and moisture. Then the next process is to turn them inside out, fill them with 'sennegræs' or sedge, if one have it, thrust one's feet in, and creep into the sleeping bag with them on. For milder weather later on, we had provided ourselves with leather boots of the 'Komager' type, such as the Lapps use in summer. . . . . Inside the Finn shoes we used at the beginning of our journey this sennegræs (*Carex æsicaria*), of which we had taken a supply, was most effective in keeping the feet dry and warm, and is used Lapp-wise, *i.e.*, with bare feet; it draws all moisture to itself. At night the wet 'sennegræs' must be removed from the boots, well pulled out with the fingers, so that it does not cling together, and then dried during the night by being worn inside the coat or trousers leg. In the morning it will be about dry, and can be pressed into the boots again. Little by little, however, it becomes used up, and if it is to last out a long journey a good supply must be taken."

Bladder sedge or *Carex vesicaria* has broad, involute leaves, the culm or stalk with the two rows of fertile spikelets containing the fruit. These are crowded together somewhat after the fashion of a willow catkin. Underneath the second spikelet is the long, lance-shaped, foliaceous bract, and higher up at the termination of the very thin stalk is the remnant of the barren florets. So far, sedges have not been much used in travelling or on voyages, and Dr. Nansen may be complimented for having brought this sedge into notice.

Screw Pine Fibre (*Pandanus utilis*, Pandanaceæ).—The red-spined screw pine plant and most other species of this genus are natives of the East Indies.

Fig. 36 is an illustration of a species of Screw Pine; the apices of the sword-like leaves are acuminate, the dorsal surface is spinose, and the margins are toothed.

The roots are composed of tough fibres, which basket-makers use to tie their work with; their spongy nature has caused them to be used for corks in parts in which the plants are indigenous.

In the South Sea Islands and the Sandwich Islands the leaves have been used for the making of mats; they are capable of being dyed different colours. The long fibres got from the parallel veined leaves are tough and suitable for cordage purposes. The Screw Pine is mentioned by Sir J. D. Hooker in his *Himalayan Journals*, where he says: "The path lay amongst thick jungle of *Wallichia* palm, prickly rattan canes, and the *Pandanus* or screw pine called 'Borr,' which has a straight, often forked, palm-like trunk, and an immense crown of grassy, saw-edged leaves 4 feet long."

A good typical example of the screw pine can be seen flourishing in the Victoria Regia House at the Royal Gardens, Kew.

Sida Fibre (*Sida rhombifolia*, Malvaceæ).—This fibre has been described by Mr. George Watt[1] as follows:—"It has a lustrous silky fibre like jute, but much finer and brighter and whiter. It is altogether much superior to jute, and could be grown in the same field and under the same conditions. The fibre is separated from the stalk by the same process as jute, and has not hitherto come into the market, simply through

[1] Mr. George Watt, M.B., C.I.E., Professor of Botany at the Calcutta University.

the enormous success of jute. People would not look at it on that account until recently, but now it is attracting very great attention. For want of a European name for the plant, I have denominated the fibre 'Sida' fibre, and this is a very easy and nice name, better, perhaps, than any other which could be given, and the one by which it would, in all probability, be known upon the market. With regard to the Rhea, or China grass fibre, as many people prefer to call it, there is one point which seems to have escaped notice. People have been devoting time and attention to the utilisation of this fibre, to the abstraction of the gummy matter, and the settlement of the dyeing problem. All

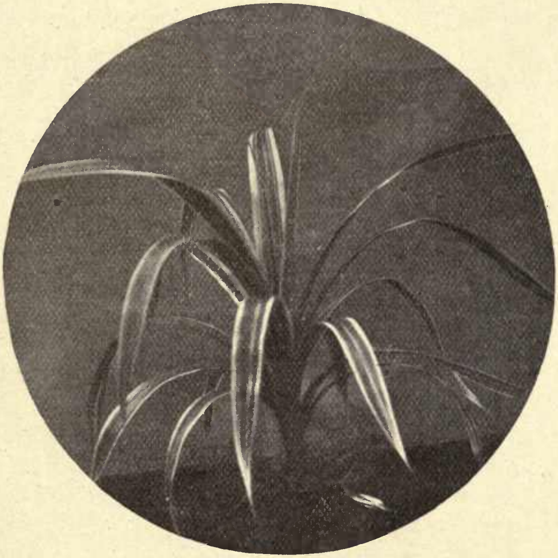

Fig. 36.—Screw Pine (*Pandanus utilis*).

these things have been a stumbling block to the pioneers of this industry; but they have never once stopped to ask if there was more than one rhea. I believe that if, instead of wasting their time trying to utilise one species, they had looked about to find some of the others, they might have found some more easily workable way." These fibres are also known as Sufet Bariata.

Screw Tree (*Helicteres Asoca*, Sterculiaceæ).—A native of the East Indies, and a member of the family *Sterculiaceæ*, introduced into England in 1733. The fruits of the plant are twisted, hence its name of *screw tree*. The fibres are derived from the bast, and are well adapted for the manufacture of cordage. They have also been used for the making of gunny bags and the blinds of verandahs. The plant was noted by Sir J. D. Hooker during his interesting Himalayan botanical journeys.

Sisal Hemp, Henequen, Yucatan (*Agave rigida*, Amaryllidaceæ).—This plant, shown in fig. 36, is the *Agave rigida*, var. *Sisalina*. The leaves are sword-like (ensiform), and terminate in a long, sharp, horny point. The fibro-vascular bundles of this plant run longitudinally from the stem to the apex of the leaves, and the fibres obtained from it yield the "Sisal hemp" of commerce. The Sisal belongs to the Monocotyledons. It has received many names, among which are Agave, Henequen, Bahama fibre, Yucatan, the latter being derived from a State of that name. In

Fig. 37.—Sisal hemp plant (*Agave rigida*).

Central America, the term Sisal is likely, however, to become the most popular. The plant is extensively grown in the Bahamas. In 1892 Sir Ambrose O'Shea, Governor of the Island of Bahama, said: "We have 100,000 acres of the Crown lands under this fibre, and the value of these lands has increased 300 to 400 per cent. When the cultivation of the fibre is fully developed, the yield ought to be 50,000 tons annually, and it is marketable at from £20 to £24 a ton." The plant has also been grown in the Wide Bay district of Queensland. The fibres have been much used for cordage, and large quantities have been exported into Australia from the United States. It has been used for the manufacture of coarse sackcloth and for hammocks.

Fig. 37 shows a plant of *Agave rigida* var. *Sisalina*, or Sisal hemp, growing in the Succulent House at the Royal Gardens, Kew. This photograph was taken by kind permission of the director, Sir William T. T. Dyer.

Fig. 38 shows the long fibres of sisal when untwisted from the strand of a small rope. Such strands have recently been put to an educational use, and have been introduced into the infant departments of public

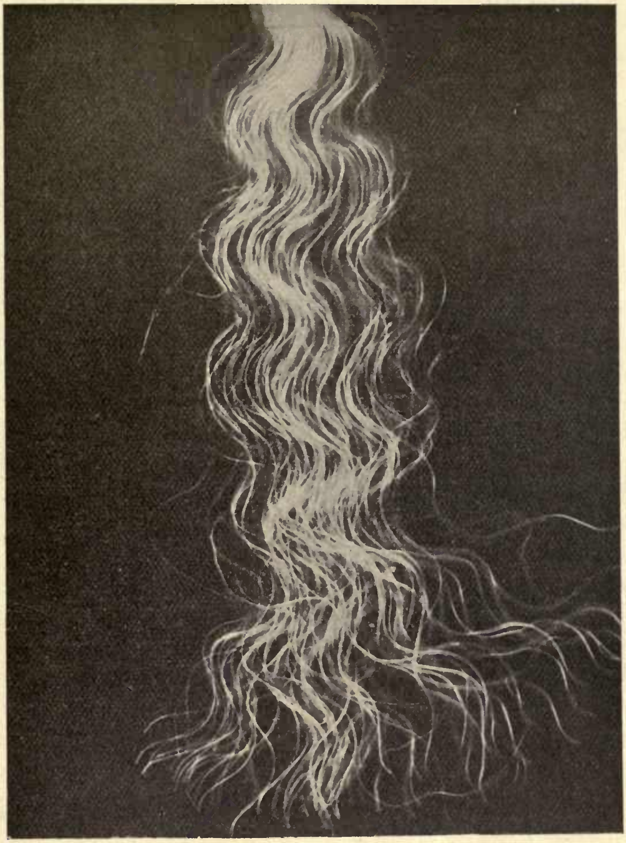

Fig. 38.—Sisal rope strand.

schools. The strands of sisal rope are untwisted and cut into lengths of 5 or 6 inches; these are made into fans or balls. The clear white colour of the rope strand of fibres is an attractive feature when used for infant exercises and drills in the kindergarten system of infant training in day schools under the department (Board of Education).

Sisal hemp fibres often have too little flexibility in rope strands.

The cost of production of Sisal hemp is from 4 to 6 cents per lb., but at times it has reached the abnormal price of 21 cents per lb., packed and shipped in Progreso.

The following table shows the exports of henequen fibre from Progreso during the three years of 1896–98, giving the number of bales and their destination:—

	1896.	1897.	1898.
United States	371,874	400,030	411,138
Great Britain	13,542	7,311	3,678
Spain	3,817	3,701	956
Germany	2,924	3,101	850
Belgium	2,211	1,937	175
Cuba	1,945	2,136	1,600
France	850	1,609	550
Italy	—	150	25
Total	397,163	419,975	418,972

Note.—The English ton may be calculated at about 6 bales to the ton.

The cleaning of Sisal fibres has caused many machines to be brought into notice. In June 1892, Consul Thos. J. M'Lain reported on fibre-cleaning machines used in the Bahamas as follows:—"The machines hitherto in use are of English manufacture principally, and they do not seem to have satisfactorily met the requirements of the case. In using these machines the leaf is presented to a scraping wheel, which removes the gum, etc., from about three-fourths the length, leaving the fibre cleaned from that portion. The leaf is then withdrawn, and the other end is presented to the wheel and cleaned in the same manner. The cleaning of each leaf thus requires two handlings by the operator, making the entire process tedious and expensive. The method is unsatisfactory, and persons interested have been looking for something better in this line. During the month of June 1891, two Americans arrived in the colony, bringing with them and introducing a new automatic fibre-cleaning machine. These gentlemen were Messrs. T. Abbee Smith, of Baltimore, and W. A. Keene, of St. Louis, the former being the patentee of the machine. It was announced that on 25th June the public would be invited to witness the operation of the machine; and on that day a large number of persons interested in the fibre industry were present, including representatives from many of the out islands, where the largest plantations are being cultivated. Considerable difficulty was experienced in getting the machine running to good advantage, owing to the fact that the somewhat old steam plant used was defective, and the pulleys and belts were not of proper size, width, etc. But, despite these drawbacks, the operation of the machine was decidedly satisfactory, and nearly all present were of the opinion that, upon the proper conditions, the machine would easily do all that was claimed for it, and that it was a most valuable improvement over all other machines in use in the colony. The new machine is entirely automatic. It grips the leaves continuously as fast as the operators can supply them, holds them firmly during the operation of cleaning, and delivers the fibre completely and beautifully cleaned at the reverse side. No reversing of the leaves or any part of the machinery is required. The operator simply supplies the leaves, and the machine does all the rest. It works smoothly, easily, and rapidly. Its capacity is enormous; one of the hand machines heretofore used here will clean about 3000 leaves in ten hours, extracting

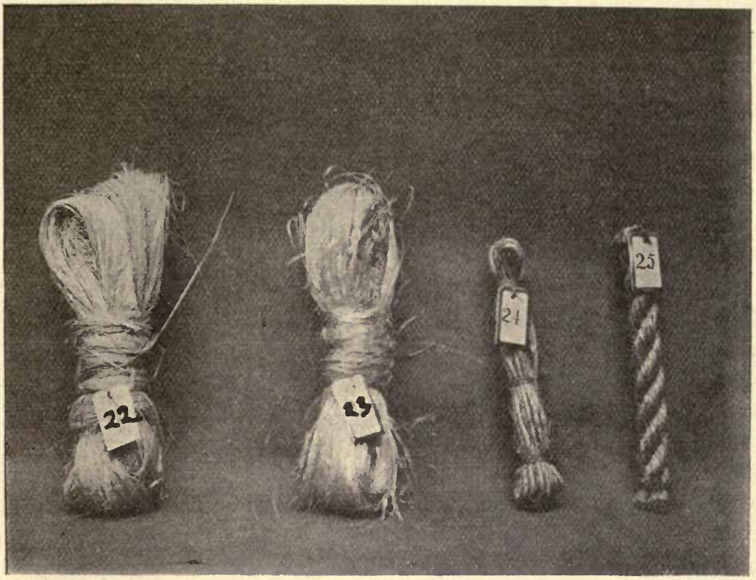

Fig. 39.—Sisal hemp (fibres and yarn).

180 lbs. of fibre; this automatic machine is said to be capable of cleaning 50,000 leaves per day, extracting therefrom 3000 lbs. of fibres. Skilled labour is not required to use the machine; an engine of 8 H.P. will furnish all the motive power required to run it at full speed. It is not a complicated affair, nor easy to get out of order. Its weight is about 6000 lbs."

In fig. 39, on this page, No. 22 shows the Sisal hemp fibres in the raw staple just as imported in the bale. The fibres or bast material have a white, straw-like appearance, rather more flat than Manila hemp, but lacking the creamy lustre of the former. Sisal hemp fibres are short of pliability, hence sisal ropes do not bend so readily.

No. 23 shows the bast fibres after heckling or cleaning.

No. 24 is sisal yarn spun out of the fibres after heckling.

No. 25 is a sample of rope made from the spun yarn shown in No. 24. It is composed of three strands well twisted together.

Soap Tree (*Quillaja saponaria*, Rosaceæ).—This interesting tree has been placed by botanists in the Natural Order Rosaceæ, the Rose family. It is a South American plant, almost restricted to Chili. It was introduced into England in 1832. The bark of the tree has been much used as a substitute for soap. A preparation of it has been employed in this country as a vegetable dressing to prevent the growth of fungi, to remove scurfiness, and as a preventive of baldness.

Soft Rush (*Juncus effusus*, Juncaceæ).—The common Soft rush has been used for platting into mats and chair bottoms, and the pith has been utilised for the wicks of candles.

The Hard rush, *Juncus glaucus*, has been utilised in the making of brooms and whisks. The leaves are not nearly so smooth as those of *Juncus effusus*; they are less pliable, fluted, and crack more readily. The hard rush generally grows in dry situations; its brittle character renders it unfit to be utilised for some purposes.

Somali-land Fibre (*Sanseviera Ehrenbergii*, Liliaceæ).—The fibres of this plant were at one time imported as "aloe fibre." According to Dr. Morris, it was identified as a species of Sanseviera in 1892, and was named by Dr. Schweinfurth *S. Ehrenbergii*, to commemorate the name of Ehrenberg, a famous botanist. The plant is a native of Africa; specimens of it can be seen growing in the Palm house and Temperate house at Kew. It has stout, rigid, glaucous leaves, terminating in a mucro or horny point at the apex. Dr. Morris says of this plant: "The fibre received in this country was described by Messrs. Ide and Christie as an excellent fibre of fair length and with plenty of life . . . . with the exception of its colour, its preparation is perfect and even as we value it to-day (27th June 1892) at £25 per ton."

To obtain the fibres of this plant to advantage, it is essential that it should be prepared directly on the spot as soon as it is gathered in its cultivated situation, otherwise it is not so serviceable.

Spathodea (*Spathodea Rheedii*, Bignoniaceæ).—A native of the East Indies, where the fibres have been used in net-making.

Sunn Hemp, India or **Jubbulpore Hemp** (*Crotalaria juncea*, Linn., Leguminosæ).—This material is derived from the bast fibres of *Crotalaria*, and is obtained from the stem by retting. The plant is a native of India, the Malay Islands, and Australia, and belongs to the Natural Order Leguminosæ. It is a cordage fibre plant. Of these fibres Mr. J. R. Jackson, A.L.S., Keeper of the Museums, Royal Gardens, Kew, says:

"The average outturn of cleaned fibre per acre has been variously estimated by some at 640 lbs., by others at 700 lbs., and at much less." The filamentous fibres are separated by a process of retting nearly similar to that used in the case of flax. Gunny cloth was made from the fibres of this plant at Mysore. Royle says that a cord 8 inches in size, of best Petersburg hemp, broke with 14 tons 8 cwts. 1 qr., while a similar rope of Sunn hemp only gave way with 15 tons 7 cwts. 1 qr.

Sunflower (*Helianthus annuus*).—An annual plant of the Order *Compositæ.* As a horticultural plant it is a well-known annual, a native of America. The fibres have been recommended for cordage purposes; possibly they lack strength, owing to the fact that the plant grows rapidly, and has a very large and heavy inflorescence to support during the time of flowering.

Sword Sedge (*Lepidosperma gladiata*, Cyperaceæ).—This plant is a native of Australia, where it grows in abundance. The stems and leaves are cut down and bleached by exposure to the atmosphere. The plant has been used for paper-making, and in its native country, *i.e.*, Australia, for making baskets and for fishing lines and other similar purposes.

Talipot or **Fan Palm, Great Talipot Palm** (*Corypha umbraculifera*, Palmaceæ).—This plant is a native of the East Indies. Loudon says: "The leaves are of great use, one being so broad and large that it will cover fifteen or twenty men. Being dried, it is very strong and limber; and though it be very broad when open, yet it will fold and close like a fan, and then is no bigger than a man's arm. The whole leaf spread is round, but is cut into triangular pieces for use. These they [the natives] lay upon their heads as they travel, with the narrow end foremost, to make their way through thickets. Soldiers all carry them, not only to shade them from the sun and to keep them dry in case of rain on their march, but to make their tents for them to lie under. . . . . The leaves also serve for covering their [native's] houses, and for writing upon with an iron style. Most of the books which are shown in Europe for the Egyptian papyrus are made from the leaves of this palm."

Tent-covers have been made of the leaves of this plant, also stools and baskets; examples are shown in cases in the Economic Museum, Royal Gardens, Kew.

Tashiari Fibre (*Debregeasia hypoleuca*, Urticaceæ).—A plant of the nettle family which grows in the Himalayas. The branches and leaves have a woolly pilose down. The fibres of the plant are chiefly used for bowstrings and for cordage.

Tibisiri Fibre (*Mauritia flexuosa*, Palmaceæ).—The fibre is obtained from the plant known as the Ita or Æta palm; the cuticle of the leaves is used for cordage and hammock-making. This palm is a native of Surinam, and was introduced into England in 1816. The leaves are digitaliform, or divided deeply down to the base; the segmental ribs, when detached, have been used for twine and cord-making, and the petioles for canoes and baskets in British Guiana. The male spadix of the plant is flexuose and over a foot long.

Touchardia (*Touchardia latifolia*, Urticaceæ).—A native of the Hawaiian Islands, a shrubby plant nearly allied to *Bœhmeria nivea*. This plant produces a fibre that is easily detached from the plant. The stem fibres are adapted for cordage purposes.

Tucum Fibre (*Astrocaryum Tucuma*, Palmaceæ).—This plant was introduced into England from the Amazon river in 1840.

In South America a very fine fibre is obtained from this species of palm. The fibre is held in high esteem. Dr. Morris says: "A fine fibre is extracted also from the leaflets of *Astrocaryum Tucuma* in tropical South America. This is knitted by hand into a compact web of so fine a texture as to occupy two persons three or four months in its completion. The handsome hammocks afterwards made from the web sell for £3 each, or double that amount."

Urera Fibre (*Urera tenax*, Urticaceæ).—The fibres of the Urera plant are made into thread or cordage. They have a resemblance to China grass, but are not so tenacious. The plant from which Urera fibres are obtained is a tree-like shrub, *Urera tenax*, belonging to the nettle family. It is a native of Natal.

Vanda Felt (*Vanda teres*, Orchidaceæ).—This plant is a caulescent orchis with very handsome flowers. It is remarkable for the very fine felted hairs which serve to carry the seeds to suitable places of growth. They are highly hygroscopic, and readily affected by moisture, differing in this respect from the animal hairs employed in making felts. Prof. Anton Kerner von Marilaun, speaking of the feltose seeds of the Vanda, says: "The hair-like cells in question are woven together into a sort of felt. They are extremely hygroscopic, and twist and twine about in a curious manner, if the slightest change of condition in respect of moisture occurs. When the valves of the capsule move apart under the influence of a dry wind, an active movement is simultaneously initiated in the matted hairs. The felt becomes to a certain extent puffed up, and consequently it squeezes out the valves of the capsule, and drags the seeds, which are imbedded amongst the hairs, from the interior to the surface of the capsule, where they are liable to be blown away by the least breath of wind. This happens, as was said, when a dry wind is blowing. In wet weather the capsules close up and conceal both hairs and seed once more in their interior."

Weed, Mallow-leaved (*Triumfetta semitriloba*, Tiliaceæ).—The inner fibrous bark of this plant has been used for cordage purposes. The plant is a native of the West Indies. The bark is of a toughish nature, and has been used for making ropes in the inland parts of the West Indies. This plant has been called the Bur Weed, but the name bur weed ought preferably to be confined to the genus *Xanthium* (*Compositæ*).

Wild Rhea or Ban Rhea (*Villebrunea integrifolia*, Urticaceæ).—This plant yields a fibre of bast structure which vies in strength and lustre with the China grass. It is grown in India, but so far has not become a favourite plant in cultivation.

Wood Date Palm (*Phœnix sylvestris*, Palmaceæ).—A native of the East Indies, from which a good many articles have been made, such as cordage, ropes, work-boxes, cigar-cases, etc. Examples of these can be seen in the Economic Museum of the Royal Gardens, Kew.

Wool Tree or Cork Tree (*Ochroma Lagopus*, Sterculiaceæ).—This plant is a native of Jamaica, where it grows into a large tree remarkable for its numerous branches and large leaves.

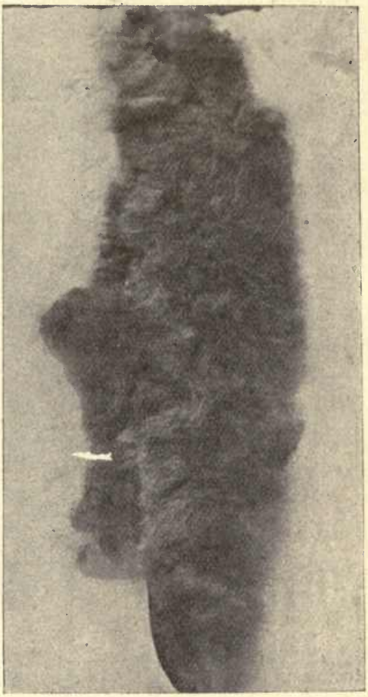

Fig. 40.—Capsule of the Wool tree (*Ochroma Lagopus*).

Loudon says: "The capsules contain a very soft rufous down in which the seeds are involved, and which down is said to be used in the manufacture of English beaver hats."

Fig. 40 is the ripe capsule covered with the wool-like fibres, and fig. 41 shows the pear-shaped seeds, which are of rather a darker colour than the wool fibres.

Some of this wool-like vegetable fibre was recently offered to a well-known Lancashire cotton manufacturer for his opinion. At his request I examined the fibres microscopically, and gave as my opinion that they would not serve for spinning into a yarn. My opinion was confirmed by a Yorkshire woollen manufacturer, who examined them from a staple and commercial point of view. The tree producing these plumose fibres is characterised by its wood, which is white and tender, and so exceedingly light that it has been used instead of corks to fishing nets, hence its name of "Cork Tree."

Some slight efforts have been made to utilise these vegetable wool fibres for the purpose of felt hat-making, but so far without success. The want of marginal dentations on the fibres has been adduced as the main reason why they are not suitable for this purpose. Nevertheless some

Fig. 41.—Seeds of the Wool tree.

use should be made of them, inasmuch as they will take a good dye, and have been blended with silk in hat-making mainly on that account.

For the specimens figured, I am indebted to C. T. Bradbury, Esq., J.P., Managing Director, Gartside's, of Manchester, Limited.

Wurzel Burste (*Polytrichum commune*).—Small brooms, used by weavers in Switzerland, have been made from the stems of this large moss, and are known under the above name (according to Mr. John Jackson, F.L.S.). This moss grows plentifully in the valleys of the moorland and mountainous districts of Lancashire and Yorkshire, and in Wales, Scotland, and Ireland. It is commonly known as the Hair Moss, but in some parts of Lancashire and in Yorkshire it is styled the "Robinson Crusoe" moss, on account of the calyptra being fringed or woolly and persistent to the capsule.

Yucatan Hemp (*Agave rigida*, Amaryllidaceæ).—The stem fibres of Yucatan hemp were formerly obtained from the *Agave rigida* or spiny-leaved species of aloe.

Fig. 42 is a photograph of the original Yucatan hemp plant, the leaves of which are lanceolate, acuminate, with a serrate or spiny margin. The dorsal side or back of the leaf is convex, and the inner side is slightly concave. The serrations on the margins of the fibre are probably a source of protection to the leaves of the plant, but

Fig. 42.—Yucatan hemp (*Agave rigida*).

these serrations are a bad feature commercially, and have interfered with the extraction of the fibre, but the variety *Sisalina* of this species has superseded the type as a fibre-producing plant.

Yucca Fibre or Adam's Needle (*Yucca gloriosa*, Liliaceæ).—A liliaceous plant, a native of America. The stem is round, and the leaves are closely crowded together, forming a kind of rosette. The leaves are dark green, lanceolate in form, sharp at the point, and entire on the margin. The flowering shoot grows from 2 to 3 feet in height, and bears a paniculate raceme of campanulate lily-like flowers of a white hue.

The illustration in fig. 43 is from a plant flowering in the open air, near the Orchid house of the Royal Gardens at Kew, in August 1898.

The plant grows wild abundantly in the districts of Florida, Texas, and Mexico. The fibres obtained from the leaves are best adapted for cordage purposes or for mat-making. The Yuccas seem to flower pretty freely in sheltered situations in the Royal Gardens. The stock plant from which the above photograph was taken was in splendid condition

Fig. 43.—Adam's Needle (*Yucca gloriosa*).

and exceeded 5 feet in height. Evidently the plant has been a long resident in the gardens, and its habit of flowering in the open air will interest provincial botanists who find time to visit Kew.

VEGETABLE SILK.

Introduction.—This is chiefly obtained from the seed-coverings of certain trees and plants having plumose hairs or seed-coverings. The hairs are very fine, with a lustre that almost equals that of silk, but the staples are short, incohesive, and of weak textures.

The hairs are cylindrical, flattened, translucent, and entire on the margins, with an absence of scales, serratures, or dentations of any kind. The silky hairs of some species, *e.g.*, Kapok, are pappus-like, and form means of dispersion of the fruits. They have a coherent base, which is an obstacle to its being spun, if only from the unequal length of the parachute tuft of silk-like fibres. Attempts have been made to use the fibres for spinning and upholstery purposes.

Of the different plants characterised by their silky hair fibres, the following may be mentioned, viz.: The Swallow-wort of North America, Kapok, Mudar, Silk Grass or Pita Fibre, Red Silk Cotton or Semal Cotton, Cuba Silk Grass, Vegetable Hair, Vegetable Silk.

Nearly all the vegetable silk fibres are plumose appendages to the fruits or seeds of the plants upon which they are borne, and in most cases they serve to assist in the dispersion of the seeds.

Kapok (*Eriodendron anfractuosum*, Sterculiaceæ) is an illustration of the light, soft, silky, flossy fibres of Kapok. It has been suggested to blend the silky, flossy fibres of Kapok with fur fibres from the Coney or the Hare in making hats; but if this were done it would be necessary to reduce the amount of fan draught, owing to their lightness, and to the fact that they are not usually charged with a heavy amount of impurities. The fibres of Kapok are thin and transparent with almost smooth surfaces, as seen under the microscope. Their uniformity of diameter is well marked. They might perhaps be worked in with other silky fibres under pressure, but this would require the use of some adhesive preparation. The fibres are extremely light, and the length less than half an inch.

Referring to the Kapok or Silk Cotton tree, Mr. John R. Jackson, A.L.S., says: "It belongs to the same natural order as the *Bombax*, and has a wide tropical distribution through India, Ceylon, South America, the West Indies, and Tropical Africa. The fruits vary considerably in size and shape; the usual form is, however, about 3 or 4 inches long by 2½ inches in diameter across the centre, tapering at both ends. When ripe and dry it has a woody covering of a yellowish buff colour, and splits open longitudinally, exposing the silky fibrous contents. Under the name of 'Kapok' this silky floss is now exported in very large quantities from Java, both to Europe and Australia. It is a trade of quite recent creation, and was started entirely by the Dutch merchants. The only use to which it is put is for stuffing mattresses and cushions, being, like the floss of *Bombax malabaricum*, too short and brittle for spinning purposes. As a stuffing material it is, however, superior to that from *Bombax*, as it is said not to mat so readily. As an illustration of the rapidity with which this substance took in the European and Australian markets, it may be stated that the exports from Netherlands India in 1822 amounted to 302,201 kilos, and in 1885 they had risen to 600,269 kilos."

Kumbi or **Galgal** (*Cochlospermum Gossypium*, Cistaceæ).—The silky fibres of Kumbi are produced in tightly packed, ovate, acuminate pods. The seeds are used for the stuffing of cushions and mattresses. The soft silky fibres are well adapted for stuffing without cohesion.

The Gumbi tree grows wild on the rough mountainous slopes in India. Sir J. D. Hooker mentions this tree in his *Himalayan Journals* as follows:—"We marched on the 28th to Kota, at the junction of the river of that name with the Soane, over hills of flinty rock, which projected everywhere to the utter ruin of the elephants' feet, and then over undulating hills of limestone. On the latter I found trees of *Cochlospermum*, whose curious thick branches spread out somewhat awkwardly, each tipped with a cluster of golden-yellow flowers as large as the palm of the hand, and very beautiful. It is a tropical Gum Cistus in the appearance and texture of the petals and their frail nature. The bark abounds in a transparent gum, of which the white ants seem fond, for they had killed many trees. Of the leaves, curious, rude leaf bellows are made, with which the natives of these hills smelt iron. Scorpions appeared very common here, of a small kind 1½ inches long. Several

Fig. 44.—Silky fibres of Mudar (*Calotropis gigantea*).

were captured, and one of our party was stung on the finger; the smart was burning for an hour or two, and then ceased."

Mudar or Yercum Fibre (*Calotropis gigantea*, Asclepiadaceæ).—Of this plant Dr. Forbes Royle says: "In the southern as in the northern parts of India, there is met with, in considerable quantities, in all uncultivated grounds, a plant with broad, rather fleshy, glaucous-coloured leaves, and which, on being wounded, gives out a milky juice from every part. This is called Ak, and Mudar in Northern, and Yercum in Southern India. Its juice and the powdered bark of its roots have long been employed as an alterative by the natives of India."

Fig. 44 is the silky stapled fibres of the seeds of Mudar.

Paper has been made of the downy substance of the follicles when mixed with the pulp of the Sunn hemp plant. An attempt to spin it has been made, mixed with one-fifth of cotton, and a tolerably good wearing cloth was prepared from it, which took the dye well. The plant grows plentifully in the southern parts of India.

Fig. 45 shows the fibres of the Mudar or Yercum as seen under a quarter-inch objective. They show a rather faint transverse marking, reminding one of the structure of China grass fibres. The fine silky staple of these fibres often appears tempting to the eyes of cotton spinners, but the staple is too slape; yet it can be drawn out to more than an inch in length. Such a staple displays its fine silk-like lustre to the best advantage.

What these fibres lack in staple they make up by having very good

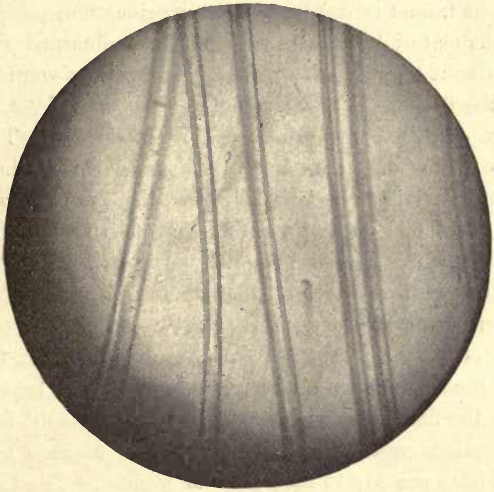

Fig. 45.—Fibres of the Mudar (magn.).

capacities for dyeing either a good deep black, a fine golden colour, and a pink or reddish tint.

For good specimens of these fibres brought from India, I am indebted to the firm of Ralph Douse & Son, Limited, Billiter Buildings, Mark Lane, London, and my dyed specimens I owe to Mr. Charles Timothy Bradbury, J.P.

All attempts to spin this fibre has so far been by mixing it with cotton or some other fibres; consequently it has proved a failure.

The very silky lustre and the good dyeing property which these fibres possess are so rich that they ought to be kept intact when trying to spin or to felt it.

In spinning it alone some of the processes ought to be omitted, and there would then be a better chance of making it into a rich, serviceable yarn.

In addition to the plumose seeds of the *Calotropis*, an important bast fibre is obtained from the stem, which is strong, fine, and lustrous. These bast fibres have been sold at 4½d. per lb. The cultivation of the plant for this purpose is not very difficult. It has been stated that three crops per year of half a ton to an acre each can be produced. The fibres have some resemblance to China grass in their length, silkiness, and rich lustre.

In August 1888 a patent was applied for by Mr. J. S. Lings and W. E. Fairlie (11481) for the manufacture of yarns or threads from the *Calotropis gigantea*, either alone or mixed with cotton wool.

It is evident from the wording of the specification, particularly where it says "fibrous materials," that the bast fibres obtained from the stem were those intended to be used; consequently they would rank as the Ak, and not the floss fibres of *Calotropis.*

Pita Fibre or Silk Grass (*Ananassa*, Bromeliaceæ).—The pita plant belongs to the genus of plants known as *Ananassa* of the Pine Apple family. It grows wild in the Brazils in the vicinity of rivers and lagoons, and on the highlands below an altitude of 1500 feet. The plant produces suckers which measure from 5 to 12 feet in height. The fibres run through the entire length of the stem or leaves. The plant is a Monocotyledon with a very tenacious rind.

The mode of preparing the fibre has been described as follows:—The Indians place the stalks upon a slab and scrape off the back of the bark (which carries the filaments) with the sharp end of a split bamboo. It is a slow and laborious process, which yields on an average not more than 1 lb. of clean fibre per day to each man or woman. The Caribs soak the stalks in water until the bark becomes partially decomposed, when it can be rubbed off quite easily; but this process is said to injure the strength of the fibre. In recent years many attempts have been made by foreigners to extract the pita fibre mechanically, and many kinds of machines have been invented for that purpose. Grants of territory and exclusive privileges have been obtained from the Government of Honduras to work the pita fields, and large sums have been expended in planting machinery and other preparatory works. In every instance such attempts have failed, owing entirely to the fact that no machine or process has yet been invented that will abstract the fibre from the pita plant on a scale sufficiently large to make it profitable.

The fibres have been used for thread for sewing boots, nets, fish-lines, halters, and some of the best kinds of cordage. The most beautiful

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hammocks have also been made of pita, some of which have sold for as much as $50.

Samples of this fibre have been sent to the United States and to Europe, where it has been manufactured into a variety of articles, such as handkerchiefs, laces, ribbons, wigs, false hair, etc. It is claimed that it can be successfully employed as a substitute for either silk or linen. It can be purchased of the Indians in the backwoods, nicely prepared in rolls or skins of about 12 ounces each, for 25 cents per roll. In the cities and towns of the interior it is sold in small quantities to shoemakers and others for $1 per pound,

The cost of preparing it for market by the native system is too great, and the quantity prepared too small, for it to become an article of export. With suitable machinery thousands of tons could be extracted from the wild pita fields of Honduras, and when these are exhausted it could be cultivated with the greatest facility.

There can be no doubt that this valuable fibre is destined to become a very important element in the future commerce and industry of America. It is intended to forward to the U.S. Department of Agriculture some samples of the fibre as prepared by the Indians, and also some leaves and growing plants, as soon as they can be obtained from the mainland. The New York and Honduras Fibre Company, after spending a large amount of money, was obliged to give up their enterprise because their fibre machine was a failure. Their plant, including an engine of 25 H.P., a sawmill, a steam barge, and a large assortment of tools and fixtures, has practically been abandoned.

Silk Cotton, Red, or Semal Cotton (*Bombax malabaricum*, Sterculiaceæ).—These flossy silky fibres are the seed-coverings of a large tree found growing in India, the *Bombax malabaricum.* The capsular fruit is inversely cone-shaped, and when ripe it opens longitudinally into four lanceolate segments. The fibres have not, so far, been used for textile purposes, but they have received some attention from hat-makers, with a view to their utilisation for felting purposes. Dr Royle says: "Hitherto the fibres have been found too short for textile purposes, and the dirty state of all consignments, burdened with the seeds, has precluded the Semal from competing with the Java apok in upholstery."

Fig. 46 is a reduced illustration of the two bony segments of the four-valved capsule in which the silky fibres are attached to the seeds, but are easily removed. The seeds are wrinkled, and the silky fibres are easily detached.

Fig. 47 shows the flossy or plumose fibres when the seeds have been removed. It is a matter for consideration whether these fibres could not be further utilised in the blending of fibres in the manufacture of, say, eider down quilts, or some other fabrics.

The red silk fibres, as seen under the microscope, are narrow, thin, short, and transparent.

Fig. 48 is a photo-micrograph of the fibres. Structurally, they are flattened and tapering, but as they dry there is a tendency to curl up. If this curliness was more marked, the fibres might be used for felting purposes. These vegetable fibres will take a good dye, and could perhaps be incorporated with silk fibres for use in some of the cheaper kinds of quasi silk fabrics.

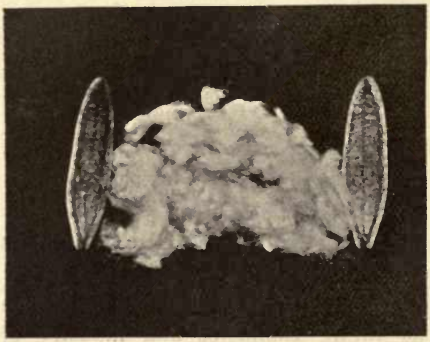

Fig. 46.—Capsules of Red Cotton Silk (*Bombax malabaricum*).

Silk Grass (Cuba) (*Furcrea cubensis*, Bromeliaceæ). — The fibres of silk grass have been used for rope-making, and at one time it competed with those of Sisal hemp. The plant is the "Silk Grass" of commerce, and the *Furcrea* of botanists.

The leaves are spathulate or somewhat ensiform in shape, with sharp points, saw-toothed margins, and a parallel venation. The *Furcrea* is not really a grass, but an aloe-like plant of the Order *Bromeliaceæ*. It is a native of South America and was introduced into this country in 1739. The leaves exceed 5 or 6 feet in length. The fibre was valued some years ago at £27 per ton.

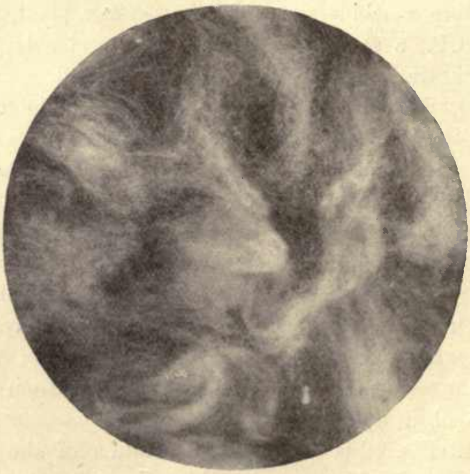

Fig. 47.—Flossy fibres of Red Cotton Silk.

Fig. 49 is from a photograph of *Furcrea cubensis* in the Succulent House at Kew. It shows the parallel veined structure and serratures.

Vegetable Hair, Spanish Moss (*Tillandsia usneoides*, Bromeliaceæ).

—Loudon says of this peculiar plant: "The stem is no bigger than a thread; the skin whitish as if covered with hoar frost, within, tough and black like a horse-hair. Many of these stick together on the branches of the ebony or other trees, superficially, by the middle, and send down on each side some of the same stems, very often a yard long, hanging on both sides, curled or twining, and winding one within another, and resembling an 'old man's beard,' whence the common name in Jamaica. The stems are branched, and the branches, which are 2 or 3 inches long, are set with roughish, white frosted leaves. The flowers are placed at the end of the branches. This curious, slender, parasitical plant is

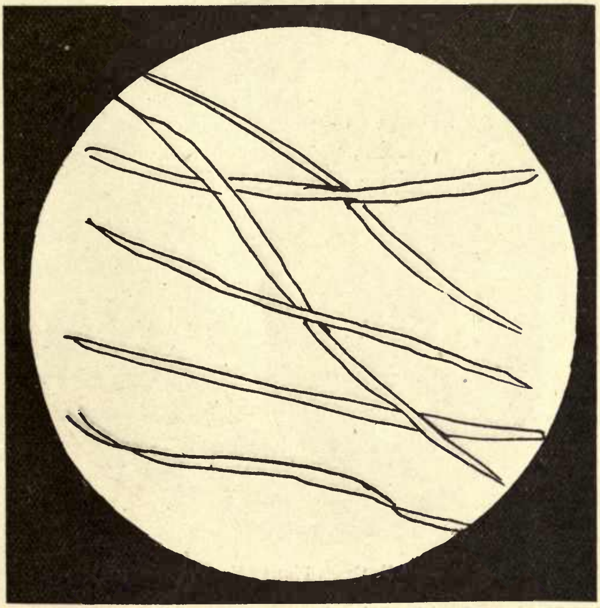

Fig. 48.—Fibres of Red Cotton Silk (magn.).

found among the trees in many parts of Jamaica, but does not grow so commonly there, nor so luxuriantly, as it does in the northern provinces of the main continent, where it is said to overrun whole forests. It is frequently imported from Jamaica to North America, for the use of the saddlers and coach-makers, who commonly stuff their panels and cushions with it. It is manufactured by tying the stalks in bunches, and sinking them in water, or burying them underground in a moist place until the bark rots. They are then taken up, boiled in water, and washed until the fibres are quite cleared of the pulp. These are often used instead of horse-hair, being so very like it that a man cannot distinguish them without a strict examination, and that even with a glass, unless he observes the branching of it." This interesting plant may be seen growing from a suspended block of wood in the No. 9 Tropical Stove House at the Royal Gardens, Kew.

Vegetable Silk (*Beaumontia grandiflora*, Apocynaceæ).—A climbing plant growing wild in the Himalayas and other parts of India. The seed hairs or plumose fibres are from half an inch to an inch long. The fibres are easily detached from the seeds, and have a white silky lustre. A good example of this plant may be seen climbing up a wire trellis in the Temperate House of the Royal Gardens, Kew.

Fig. 49.—Silk Grass Plant (*Furcrea cubensis*).

Sir J. D. Hooker, in his *Himalayan Journals*, mentions this plant as follows :—" The magnificent apocyneous *Beaumontia* was in full bloom, ascending the loftiest trees, and clothing their trunks with its splendid foliage and festoons of enormous funnel-shaped flowers." Evidently Sir Joseph was captivated by the splendid foliage and magnificent flowers, and probably the silky fibrous seed-coverings were not then conspicuous.

Vegetable Silk (*Strophanthus*, Apocynaceæ).—This is a vegetable silk, of which there are several interesting species, all peculiar for plumose silky fibres, which aid the dispersion of the seeds by the wind. The species which produces this vegetable silk is rather doubtful at present. It is no easy matter to name species of vegetable silk fibres at a glance with the naked eye, even by the most expert of commercial botanists. The form, shape, colour, weight, and texture of the seeds are often regarded as a good sign in determining the species, owing to the close similarity of the fibres.

Yachan or **Silk Fibre** (*Chorisia insignis*, Sterculiaceæ).—Vegetable silky hairs are obtained from the seeds of this plant. The fibres have the property of swelling out when put into water, and are used by the natives of the Mataco Islands for padding and protective purposes.

Up to the present time no species of vegetable silks have been discovered with spiral fibres like those of cotton, and so long as this is the case, vegetable silk for spinning purposes must remain at a discount.

COTTON.

Descriptive.—Cotton fibre is the product of four species belonging to the genus *Gossypium* of the Natural Order *Malvaceæ* or Mallows.

Some authors have, however, split them up into twelve or thirteen species, notably Parlatore, an Italian botanist.

The four species recognised commercially are :—

1. *Gossypium hirsutum.*
2. ,, *Barbadense.*
3. ,, *Peruvianum.*
4. ,, *herbaceum* or *Indicum.*

G. hirsutum yields the principal medium staples of American cotton used for spinning the medium counts of yarn known as "Oldham Counts," about 34s. to 46s. twist, and 36s. to 54s. weft.

G. Barbadense is the source of the strong, long-stapled cottons (Brown Egyptian) used for fine yarns, and known to the trade as the "Bolton Counts" also fine and extra fine counts from Sea Islands cottons.

From *G. Peruvianum* are obtained the strong, long-stapled Brazilian varieties, used chiefly for spinning the yarns of medium fine counts, of about 45s. to 70s. twist and weft.

G. Indicum produces the shorter-stapled cottons used for the spinning of low classes and waste counts of yarn. The latter are sometimes known in the trade as *condenser yarns*, and have been used for flannelettes.

In America, India, and Egypt the cotton plant is cultivated as an annual, but in the Brazils the plant assumes an arborescent or tree-like form, and produces cotton bolls for several years in succession; it is therefore termed a perennial plant.

Fig. 50 is a young seedling cotton plant showing its two entire cotyledons or first leaves, and its tap root and branching rootlets, by which it is firmly fixed in the soil. The millions of absorbent root-hairs on them serve as nutritive organs. The stem of the cotton plant grows generally to a height of from 4 to 6 feet (excepting the Brazilian species). It has numerous axillary branches which lengthen in growth. These produce the first flowers and cotton pods. The leaves are often alternate, palmate, or ternately segmented, and tomentose on the ventral and dorsal surfaces.

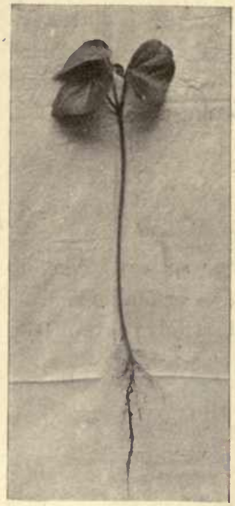

Fig. 50.—Seedling cotton plant (*Gossypium*).

Fig. 51 is a leaf with three lobes and a feathered venation. The flowers resemble those of the Hollyhock and *Hibiscus.* The sepals of the flower are united into a cup-like calyx with three, four, or five segments. These alternate with a similar number of leafy and fringed bracts. The bracts serve as an outer protection to the flower when in the bud, and the segments of the calyx protect the coloured part of the flower, known as the corolla.

The five petals are mostly white, but yellow at the base, egg-shaped in form, and are slightly united at their base to the staminal tube.

The stamens and carpels are numerous, each united into a bundle. They come to maturity at different periods, thereby promoting crosspollination in the flower.

The pollen grains of the cotton plant have spinose surfaces. These are shown in fig. 52, as seen under the microscope and enlarged. Pollination is effected by moths, which visit the flowers during the night. The flowers are therefore entomophilous or insect fertilised. The coloured parts of the flower are of very short duration, lasting only for about twenty-four hours.

Fig. 53 shows the partly matured and fully matured capsules of the cotton plant. The immature one is pear-shaped in form, with glandular perforations. In its green state it has three or four divisions (sutures) or deep lines; these form the segments of the boll at a later stage. The matured capsule shows the segments expanded and the four carpels of seed cotton.

The boll of the cotton plant is the fruit. Each cavity of the ovary contains a limited number of seeds surrounded by hairs, forming a covering to the individual seeds.

The quantity of seeds and hairs contained in each cavity of a cotton pod constitutes the seed cotton in the pod or boll. American, Egyptian, and Brazilian pods are larger than East Indian, and the number of segmental openings is from three to five.

Fig. 54 shows three capsules of Australian cotton and five examples of seeds with their plumose fibres attached ; also two seeds in a half ginned stage. Of the three capsules, two are shown fully opened, and the middle one shows the five segments and the same number of carpels into which the fruit of the compound ovary is divided. These large capsules

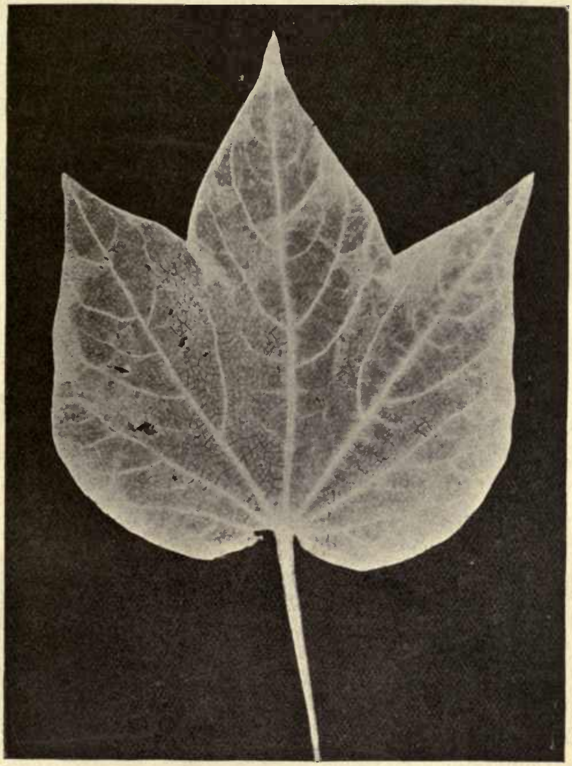

Fig. 51.—Leaf of cotton plant.

of cotton were grown on the banks of the Clarence river in Australia, and were sent to Mr. J. P. Attwater, of Preston. I was requested by Mr. Attwater to examine the samples sent, and jointly with Mr. Daniel G. Isherwood, of Ashton-under-Lyne, we gave a scientific and commercial report, which appeared in the *Preston* and *Manchester Guardians* some time later.

The geographical features and climatic conditions of Australia are hardly suitable for the growing of cotton, and lately the attention paid to its cultivation has been rather quiet. East Indian cotton pods may be reduced to four or three segments, and often only three carpels are found in the capsule or boll.

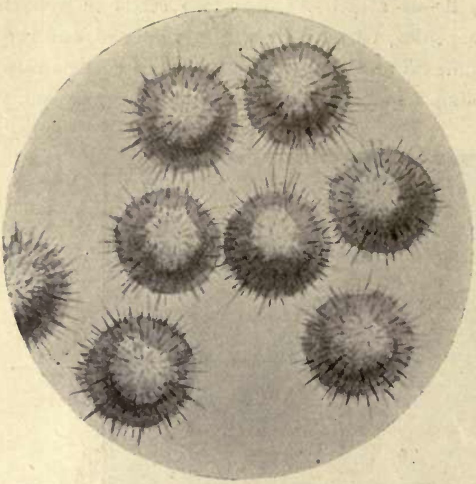
Fig. 52.—Pollen grains of cotton plant (magn.).

Fig. 55 shows a few East Indian capsules and some seed cotton. The segments vary from three to five. The black spots shown in the white carpels are insect-stained portions. These samples were collected by Mr. Hatton, of the Baroda Mills, India, and sent over to this country to John Andrew, Esq., *Reporter* Office, Ashton-under-Lyne.

Fig. 56 is a twig of an American cotton plant with two capsules fully opened, and one showing the segments or capsules separating from one another in the opening fruit. There is no fracture or bursting of the fruit by the pressure of the fibres from the inside, as is sometimes stated. The opening of the capsule does not depend upon the pressure within, but rather on the drying up of the coherent membrane sutures or valves of the capsules.

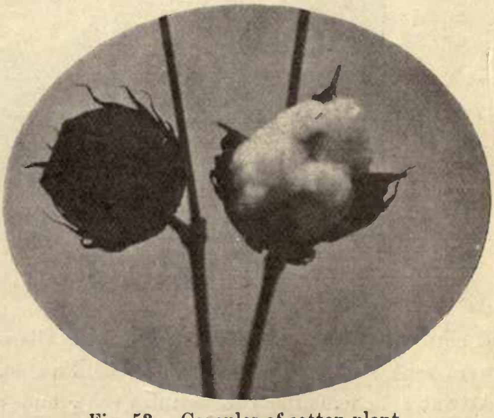
Fig. 53.—Capsules of cotton plant.

Fig. 57 is the upper part of a twig from an American plant which was shown in competition at the last Cotton Centenary of America. The large bolls, heavily laden with seed cotton, were displayed on the plant, fully ripe. It won the blue ribbon at the Centenary, and the whole plant, with the ribbon attached, was sent to a cotton broker in Liverpool, who presented it to the late

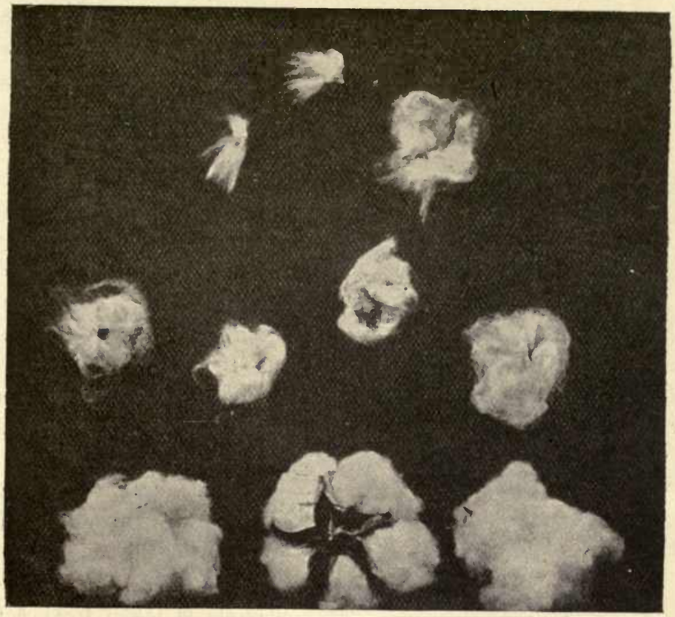

Fig. 54.—Pods and seeds of Australian cotton.

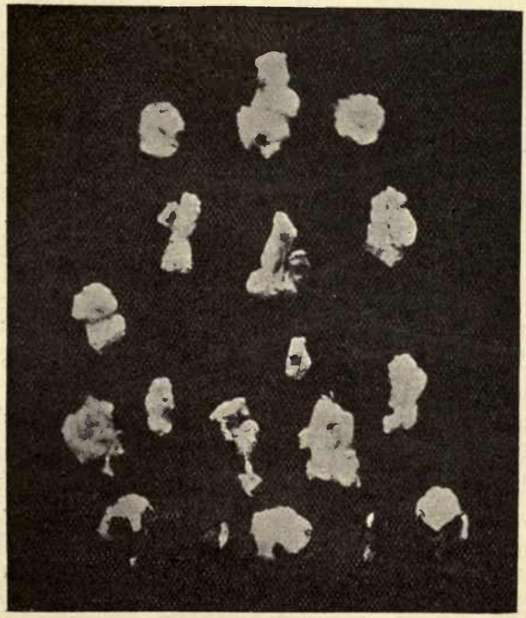

Fig. 55.—Pods and seeds of Indian cotton.

William Hague, Esq., of Ashton-under-Lyne. The illustration shows the masses of cotton, mature and of immense size. The pearly-white fibres enclosing the seeds are gracefully suspended from the capsules of the cotton twig. It is certainly creditable to American cotton-growers to produce such a fine example of capsules in a stage of full dehiscence.

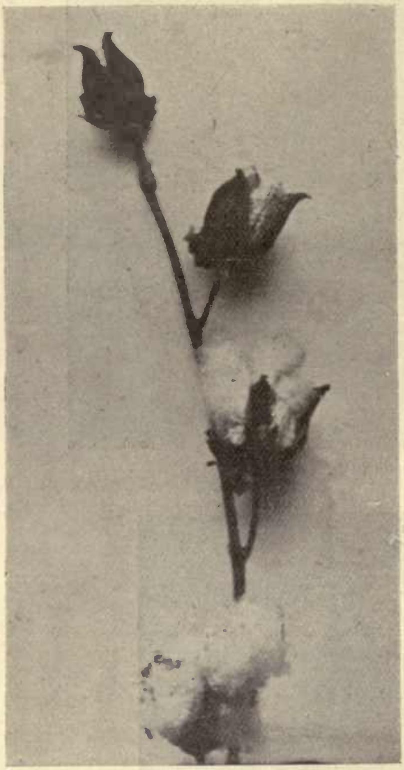

Fig. 56.—Twig from American cotton plant.

Fig. 58 is a section cut longitudinally through a young cotton capsule, showing the fine cotton seeds also cut through, and the white fibres in the interior of the pod. The stalk of the capsule shows a node or joint which is thickened. It then tapers to the point of insertion. The leaf-like expansion shown on the right is a fringed foliate bract. This example is taken from a plant grown by Mr. Wm. Hough, gardener to Abel Buckley, Esq., J.P., Ryecroft Hall, Ashton-under-Lyne.

Fig. 59 is a photo-micrograph of fibres taken from the interior of one of the immature capsules of the previous illustration. When the fruit is immature and in a growing state, it has a moist or turgid condition internally, and the fibres have then a flattened, flabby appearance, as shown, also a flexibility and softness evidently peculiar to unripe and immature cotton fibres.

A cotton seed has two or three membranous coverings—the outer one through which the fibres penetrate, an intermediate one to which the fibres are attached, and a chocolate-coloured or corky membrane which surrounds the kernel of the seed and prevents the oil from the glands of the kernel oozing through the membrane and staining the cellulose fibres. These glands are the source of the cotton seed oil of commerce. Cotton seeds are conical or egg-shaped, with a plumose covering of hairs or fibres. Their attachment to the seed is typical of the genus.

Fig. 60 shows American cotton seeds with the fibres attached, known in this state as Seed Cotton. Close to the seed is a short downy coating

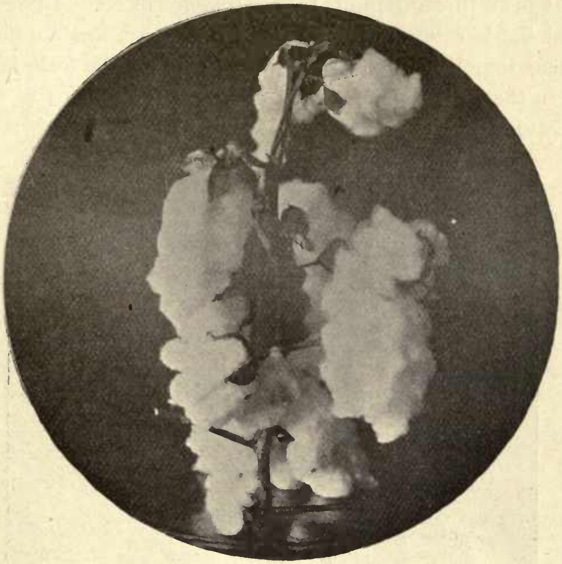

Fig. 57.—Unusually large cotton capsules.

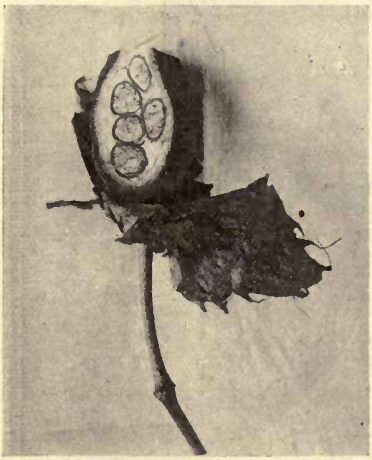

Fig. 58.—Section of a cotton seed-pod.

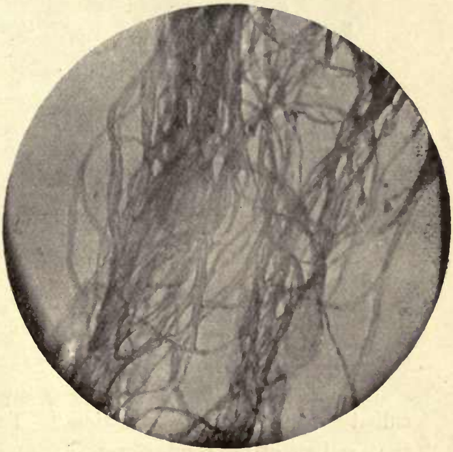

Fig. 59.—Fibres from an immature cotton seed capsule.

of hairs in addition to the general bulk of fibres. The fibres of American cottons are easily detached from the seeds during the process of ginning, *i.e.*, removing the fibres from the seeds. For these American samples I am indebted to John Metcalfe, Esq., Astley Mill Co., Limited, Dukinfield, Cheshire.

Fig. 61 is an illustration of Brazilian seed cotton. These seeds have a brownish-black colour; they are oblong in form, finely fluted, and the seeds cohere together in the masses of cotton in the form of a kidney, as shown in the six examples. This character has given rise to the term Kidney Cotton, which is peculiar to the Brazils.

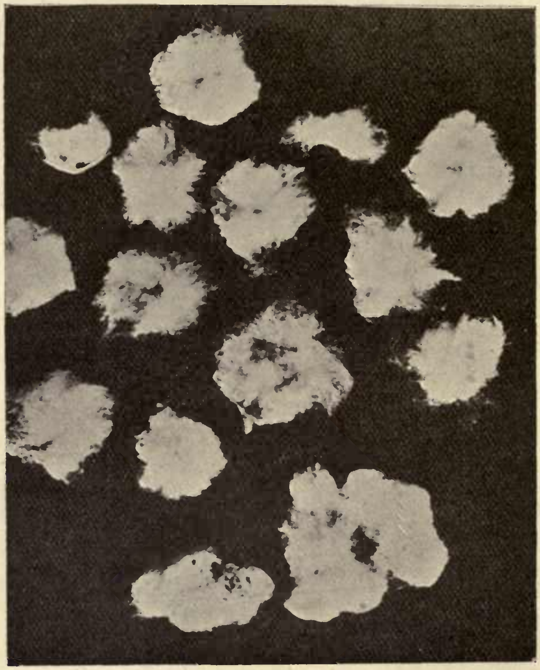

Fig. 60.—American cotton seeds with fibres.

Fig. 62 shows the Brown Egyptian or black-seeded cotton. The fibres are long in staple, but slenderly attached to the seeds. They are mostly cleaned by the "Roller" or the "Macarthy" cotton gins.

The Egyptian, Sea Islands, and the Australian cottons are sometimes called "the black-seeded cottons." They are all of long staples, and are the product of *G. Barbadense*.

East Indian or Surat cotton seeds have a dense downy covering and shorter than the seeds of other species. As a rule, the fibres of East Indian cottons are short in staple, but strongly attached to the membrane of the seeds, and are therefore much harder to gin, particularly in the variety known as Scinde cotton.

Structure of Cotton Fibres.—Cotton fibres are composed almost entirely of pure cellulose, each being a unicellular hair. The wall of the fibre is lined by a delicate layer of protoplasm or living substance.

The cell-wall of the cotton hair grows by the accretion of new cellulose material formed from the protoplasm.

Fig. 63 shows a number of cotton fibres highly magnified. Fully ripe, they are slightly twisted, and resemble to some extent a miniature stick of barley-sugar. This spiral appearance is always a characteristic of fully ripe cotton fibres.

Of the four specimens shown in the illustration, the one on the right

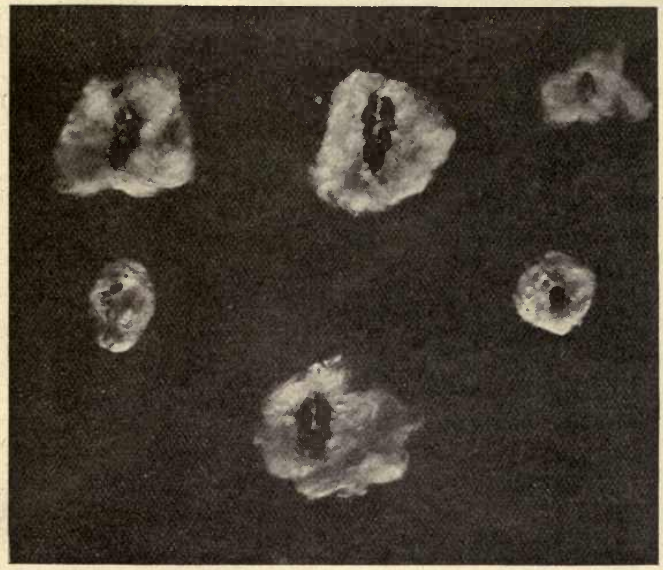

Fig. 61.—Brazilian seed cotton.

is a "Kempy" fibre, *i.e.*, one that has been interrupted or crippled in its growth. There is generally a less amount of twist in one part than in the other, as can be seen by observing the point at which the interruption occurs. These Kempy fibres do not take dyes so readily as do those which are fully ripe.

Fig. 64 shows three fully ripe fibres of Sea Island cotton. The diameter of the fibres is remarkably uniform, and the spiral form very distinct. When fibres are not ripe they become rod-like, with the spiral feature suppressed. The want of this is a detriment to the spinning of a good and reliable yarn, particularly in the finely-spun yarns for which

Sea Islands fibres are generally used. The length and the strength of cotton fibres varies considerably, according to the situation and the country in which they are grown. The strength of the cotton fibre relative to its size is fairly great. As a rule, the thickest fibres, though short in staple, are the strongest.

East Indian fibres are not always well adapted for closely twisting yarns.

The great strength of East Indian cottons is mainly due to their having this property, but much of it is lost when such fibres are twisted with those of American cotton into a yarn. According to the tests made by the late Mr. Charles O'Neil, the breaking strain of two principal growths of fibres is as follows: Sea Island, 83·9 grains; Surat cotton, 163·7 grains.

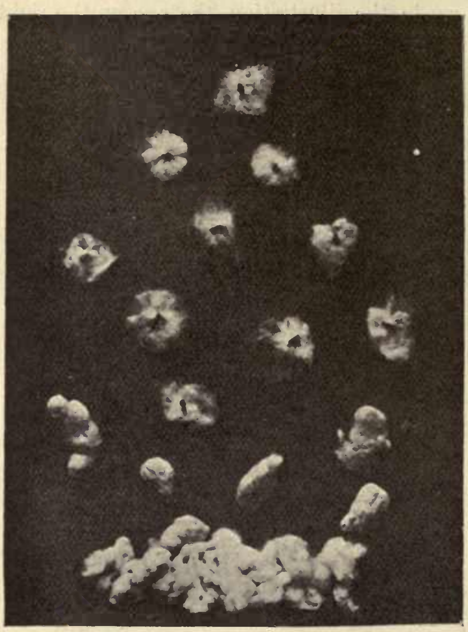

Fig. 62.—Brown Egyptian seed cotton.

In the spiral structure of cotton fibre the margins are more thickened than the central portions. Ripe fibres are more twisted than unripe ones. This is probably due to the deposition of material on the inside of the cell-wall taking place on two sides alternately, so that when the protoplasmic elements are withdrawn from the wall, there is a collapse of certain parts of the cellulose, causing the fibre to appear spiral or twisted. The shape of the fibre, as seen in transverse section, is oblong, half-moon-shaped, triangular or dumbbell-shaped, the last being that most characteristic of a fully ripe fibre, and the circular that of an unripe fibre. In the ripe fibre a fistulose structure is apparent, but in the unripe fibre this is seldom evident.

Crops.—Cotton fibres of the new season's crop are sometimes bloomy staples, indicating that there is some deception in the strength of staple, and that it is slape and weak, although the lustre is highly effective. Some of the fibres will fail to take the dye, so that in indigo and alizarinedyed cotton cloth there are occasionally white specks, which are known to dyers as "Dead Cotton." Such cotton, when seen in the staple, has a matted, wrinkled, and dense appearance. This kind of cotton can readily be detected by buyers, to whom it is known as "Gin Cut staple," or unripe, half ripe, and "Dead Cotton."

Impurities.—The several kinds of foreign impurities met with in raw cottons include bracts, sand, seed, leaf, motes, and damp or lossy staples. When sand is mixed with the cotton it is termed the "Dead

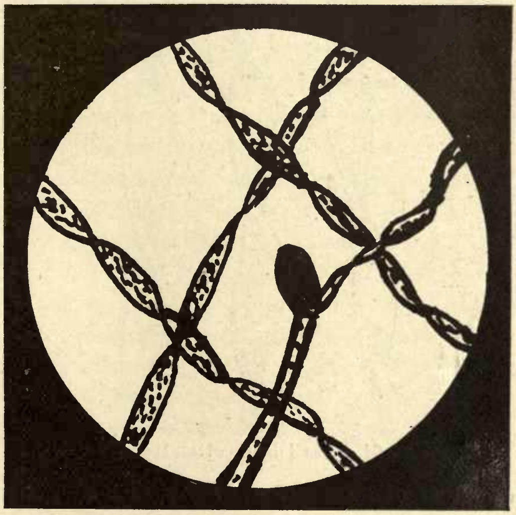

Fig. 63.—Cotton fibres (magn.).

Loss," and when it contains an excessive amount of moisture it is termed an "Invisible Loss."

Moisture.—The amount of moisture contained in cotton as offered on the market varies from $7\frac{1}{2}$ to $12\frac{1}{2}$ per cent. over absolute dryness, but anything over $10\frac{1}{2}$ would be considered excessive, and entitle the purchaser to an allowance for excessive moisture. This question has been carefully dealt with by Mr. C. T. Bradbury, J.P., Managing Director of "Gartside & Co. of Manchester, Limited," who made a number of experiments to determine what should be considered a reasonable amount of moisture in cottons. He found that ordinary raw cotton, after being exposed for several days in the ordinary process of manufacture to the working temperature of a mill, viz., from 70° to 80° F. (21° to $26\frac{1}{4}$° C.), till a balance of moisture was obtained, and then placed for twenty-four hours on the ground floor of a building open to the outer air, absorbed from 1·6 to 3·6 per cent. of moisture, the amount varying with the state of the weather. In other words, cotton in its ordinary marketable condition would lose moisture in the course of manufacture about 5 per cent., and afterwards the yarn made from it, exposed for some time to a Lancashire atmosphere, would regain from 2 to 4 per cent. of moisture.

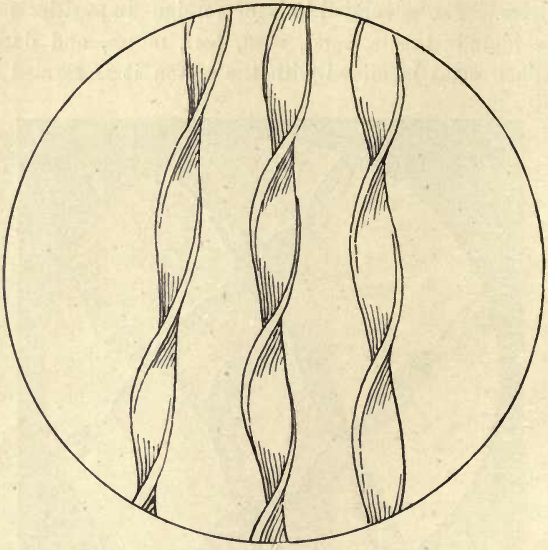

Fig. 64.—Sea Island cotton seed fibres.

Out of a number of tests recently made with cotton as bought, the following percentages of moisture (over and under the standard) were obtained, the standard being $8\frac{1}{2}$ per cent. over absolute dryness :—

Over.	Under.	Over.	Under.
1·5	·2	2·3	·1
2·0	·5	·8	·2
·7	·5	·2	
·5	·8	2·4	

These are fair moisture results. But cotton is sometimes sold with much more moisture than these figures show.

Chemical Properties.—Cotton fibres consist of cellulose associated with some 3 per cent. or less of substances (including colouring matter, pectin, wax 0·1 per cent., and albuminous matter) which can be readily removed from the fibre.

Cellulose is a compound of carbon, hydrogen, and oxygen, having the chemical formula *n* $(C_6H_{10}O_5)$, and belonging to the carbo-hydrates. In a pure state cellulose is tasteless and odourless. It is combustible. Smouldering cotton gives off the peculiar odour of acrolein. Cellulose undergoes an important change when treated with Schweitzer's solution (an ammoniacal solution of cupric hydrate).

The late Mr. Chas. O'Neil, of Manchester, made some experiments upon cotton fibres under the influence of Schweitzer's solution. Under the microscope, he noticed, first, the outside membrane which did not dissolve in the solution; second, the real cellulose beneath, which dissolved, first swelling out enormously and dilating the outside membrane; third, spiral fibres or markings apparently situated in or close to the outside membrane (or coating), not readily soluble in the copper solution and not so elastic as the material of the outside membrane, but acting as strictures upon it; these produced bead-like swellings of a most interesting appearance; fourth, an insoluble matter occupying the core of the cotton hair, which very much resembled the shrivelled matter in the interior of quills prepared for making pens.[1]

If the conclusions arrived at by the late Mr. Chas. O'Neil are accurate in every detail, then the structure of the vegetable cell or cotton hair is perhaps more complex than those of living plant cells generally. Mr. John Butterworth, F.R.M.S.,[2] of Shaw, Lancashire, also made some investigations upon the cotton fibre, and has shown that spiral markings may be seen very clearly upon them. If cotton fibres are treated with concentrated sulphuric acid they swell up and form a gelatinous mass, and the addition of water causes a precipitate to be formed. This material, which has been called amyloid, forms the basis of vegetable parchment.

Collodion is obtained from cotton by acting on it with nitric acid. The action of nitric acid upon cotton is variable, depending upon the mode of application. If applied hot, it decomposes the fibres or converts them into oxalic acid; if applied cold, it may be converted into nitro-cellulose, from which the highly inflammable product pyroxylin or gun-cotton is manufactured. Nitro-cellulose has been used for making artificial silk.

Acids have so destructive an effect on cotton fibres that their use in the cotton industry ought generally to be dispensed with, since alkalies, such as soap, borax, ammonia, and phosphate of soda, can be employed for scouring and cleaning cotton fibres without materially injuring them. In boiling cotton with caustic alkalies the air ought to be excluded and the goods kept well under the surface of the liquid, otherwise defects will be caused in the bleaching of the goods.

Mercerised Cotton.—The fibres of cotton, when immersed in a solution of caustic soda of a density of 45° to 50° Twaddell, undergo an important change. The cell-wall of the multiple fibres that make

[1] See Marsden's *Cotton Spinning*. [2] Now deceased.

up a spun yarn have the property of swelling out, and acquire a glossiness that causes the yarn to have a silky appearance. Material so treated is known in the trade as mercerised fibres and yarns. The swelling of the fibres causes a shrinkage in length; the fibres are more transparent, and gain something in strength and in weight; their capability for taking up certain dyes is increased, particularly the dyestuffs of the "Congo Red" group.

Fig. 65 shows the pearly-white and silky lustre or gloss of a lea of 2/60s mercerised yarn. At first the process of mercerising had the

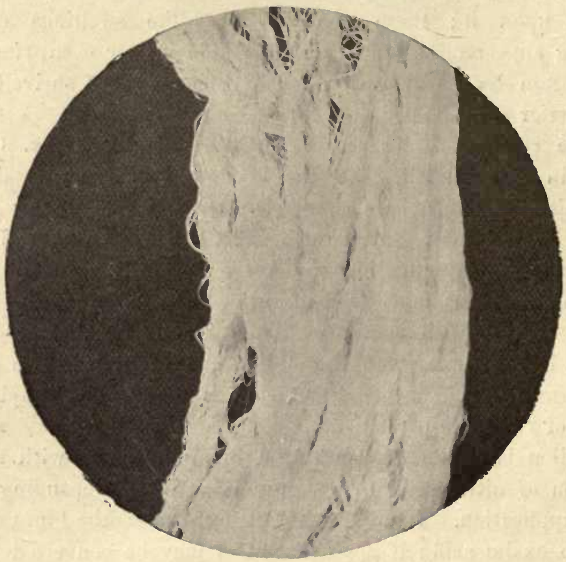

Fig. 65.—Mercerised yarn.

effect of causing some shrinkage, but recently this difficulty has been overcome, as was the case in the example shown in the illustration.

Fig. 66 shows the yarn from the same hank spread out to the best advantage for allowing the fullest amount of light to fall on the yarn hank crossings. For these samples of mercerised yarns I am indebted to Mr. Geo. H. Hurst, F.C.S., of Manchester. When mercerised yarns are magnified under the microscope, the inter-spaces in the screw line of the twist are well marked, and the fibres of the yarn spread out from the marginal surface and allow the light to penetrate. Very recently a company has been floated for carrying out the process as applied to finishing of mercerised yarns. The demand for these yarns has grown considerably; they have been keen competitors with silk for some time, and as a result of their sale the price of silk has been caused to fluctuate and become lower.

In some cases the price of mercerised yarns has reached 2s. 3d. per pound. It now remains to be seen whether the demand for it will be kept up. This will depend upon the activity of the fancy cloth trade in general.

Tanning substances, such as sumach, divi divi,[1] and chestnut are used for the purpose of mordanting.

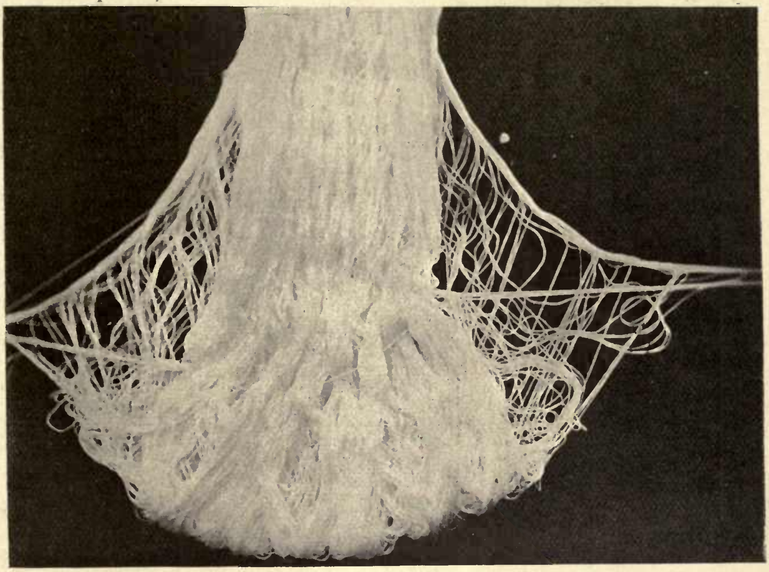

Fig. 66.—Mercerised yarn spread out.

Cotton fibres have some affinity for vegetable dyestuffs, such as Indigo, Turmeric, Safflower, and Annatto, but little or none for coal-tar dyes.

Classification of Cottons.—The types of cotton produced from plants of certain districts, the varieties, length of staple, and diameter of the individual fibres, and the counts the respective staples will spin, these influence the prices in classification.

The physical properties and the varieties of the various staples may be laid down as follows:—

[1] The seed legumes of *Cœsalpinia coriacea* of the order Leguminosæ.

Varieties and Properties of Cottons.

Types.	Variety.	Length. Inches.	Diameter. Inch.	Counts.	Twist or Weft.	Properties or Staple.
Sea Island	Edisto	2·20	$\frac{1}{1570}$	300s.–400s.	Twist or weft	Long, fine, silky, and of uniform diameter.
	Florida	1·85	...	150s.–300s.	Twist or weft	Shorter but similar to above.
	Fiji	1·75	...	100s.–250s.	Twist or weft	Less uniform in length, but silky and cohesive.
	Tahiti	1·80	...	...	...	Good, fine, and glossy staple.
Egyptian	Brown	1·50	$\frac{1}{1450}$	120s. downwards	Twist and brown wefts	Long, strong, highly endochromatic.
	Gallini	1·60	$\frac{1}{1500}$	250s. downwards	Strong twist	High-class staple of good strength.
	Menouffieh	1·50	...	200s. downwards	Brown weft	Of good staple and lustre.
	Mitaffifi	1·25	...	100s.	Twist or weft	Fairly good staple.
	White	1·0	$\frac{1}{1280}$	70s. downwards	Twist and white wefts	Pearly white, good bony staple.
Peruvian	Rough	1·25	$\frac{1}{1280}$	50s.–70s.	Twist	Strong, woolly, and harsh staples.
	Smooth	1·0	...	50s.–70s.	Weft	Less woolly and softer staple.
	Red	1·25	...	40s.–50s.	Twist.	The brown colour of this staple is weaker and harsher than Brown Egyptian.
Brazilian	Pernams	1·50	$\frac{1}{1265}$	50s.–70s.	Twist	Strong, harsh, and wiry.
	Maranhams	1·15	...	50s.–60s.	Twist	Harsh and wiry.
	Céara	1·15	...	60s.	Weft	Good, white, and cohesive staple.
	Paraiba	1·20	...	50s.–60s.	Twist or weft	Fairly strong, harsh, of good colour.
	Rio Grande	1·15	...	40s.–50s.	Weft	Soft, white, and harsh staple.
	Maceio	1·20	$\frac{1}{1180}$	40s.–60s.	Twist or weft	Soft, pliable, and good for hosiery.
	Santos	1·30	...	50s.–60s.	Weft	Exotic from American seed, white and silky staple.
	Bahia	...	...	40s.–50s.	Twist or weft	Fairly strong, but harsh and wiry.
	Aracajua	...	...	...	...	......
	Aracatti	...	...	...	...	......
American	Orleans	1·1	$\frac{1}{1290}$	34s.–46s.	Twist or weft	Of medium length, pearly white, of various grades in staple.
	Texas	1·05	...	32s.–40s.	Twist or weft	Similar to above, but rather more harsh and glossy.
	Allanseed	1·20	...	50s.–60s.	Twist	A good white colour, long, adapted to blend with Brown Egyptian in times of scarcity.

Varieties and Properties of Cottons—continued.

Types.	Variety.	Length. Inches.	Diameter. Inch.	Counts.	Twist or Weft.	Properties or Staple.
American	Mobile	1·0	$\frac{1}{1310}$	40s.–50s.	Twist or weft	Even-running staple, soft and cohesive.
	Norfolks	1·0	...	40s.–50s.	Weft	Adopted for Oldham counts of 50s., and when spun, up to 54s.
	St. Louis	0·9	...	30s.–32s.	Twist	Staple rather irregular and glossy with shorter fibres.
	Ronoaks	0·9	...	30s.–34s.	Twist	A white and strong staple.
	Boweds	...	...	36s.	Weft	Similiar to Uplands.
	Benders	1·10	$\frac{1}{1290}$	60s.	Twist	Strong, creamy or white, for turkey-red dyes.
	Memphis	1·0	...	40s.–50s.	Twist	Often bluish-white, adapted for extra hard twists.
	Peeler's	1·25	$\frac{1}{1300}$	60s.–80s.	Weft.	A long silky and fine staple, well adapted for velvets of a pilose face.
	Uplands	1·0	$\frac{1}{1290}$	36s.–40s.	Weft	A glossy staple when clean, at other times dull, sandy, and broadly leafy.
	Alabama	0·9	...	26s.–30s.	Twist or weft	Shorter staple than the above, of less strength and varying colour.
	Linters	...	...	8s.–10s.	Weft	Short-stapled gin waste.
	Tennessee	0·9	...	28s.	Twist or weft	Of varying staple in length and colour.
Greek	Smyrna	1·25	...	36s.–40s.	Twist	Rather harsh, strong and well adapted for double yarns.
African	Lagos	0·80	...	20s.–26s.	Weft	Dull in colour, often oil-stained, irregular in length and in strength.
West Indian	Carthagena	1·5	...	26s.	Twist	Grown from exotic seeds, moderately strong.
	La Guayran	1·20	...	40s.	Twist or weft	Irregular, short, but silky staple.
China	China	1·0	...	30s.	Weft	Rather harsh, short and white.
Australian	Queensland	1·75	$\frac{1}{1500}$	120s.–200s.	Twist or weft	Long, white, silky, fine diameter. See Article.
East Indian	Oomrawuttee	1·0	$\frac{1}{1200}$	26s.–32s.	Twist	Short, strong and white.
	Hingunghat	1·0	...	28s.–36s.	Weft	One of the best white Indian staples.
	Comptah	1·05	...	...	Twist or weft	Generally dull or charged with leaf and bracts.
	Broach	0·90	...	28s.–36s.	Weft	Similar to Hingunghat, produces a good white weft.
	Dharwar	1·0	...	28s.	Twist	Exotic cotton from American seeds.
	Assam	0·50	...	15s.–20s.	Twist	White, but very harsh. To blend with other cottons.
	Bengals	0·80	...	20s.–30s.	Twist or weft	Dull or charged with bracts generally.

Varieties and Properties of Cottons—continued.

Types.	Variety.	Length. Inches.	Diameter. Inch.	Counts.	Twist or Weft.	Properties or Staple.
East Indian	Bilatee	0·50	...	10s.–20s.	Twist or weft	Weak, brittle and coarse in staple.
	Dhollerah	0·70	...	15s.–20s.	Twist or weft	Strong, dull, cohesive staple.
	Surat	0·60	...	10s.–15s.	Twist or weft	Dull, leafy, often stained by boll or by larvæ.
	Scinde	0·50	...	Up to 10s.	Twist or weft	Very strong, short, dull and poor staple.
	Tinnevelly	0·80	...	24s.–30s.	Twist or weft	A lustrous white and soft staple, adapted for hosiery.
	Bhownuggar	1·0	...	28s.–30s.	Twist	White when clean, leafy and dirty.
	Comptah	0·50	...	Up to 10s.	Twist or weft	Moderately strong.
	Cocoanada	0·70	...	10s.–14s.	Brown low wefts	Brown, rather dull, and used as a quasi Egyptian.
	Bourbon	1·0	...	30s.	Weft	Exotic cotton of good staple, scarce.
	Khandeish	0·80	$\frac{1}{1200}$	20s.–26s.	Twist or weft	Similar in staple and class to Bengal.
	Madras or Westerns	0·70	...	15s.–20s.	Twist or weft	Used for low yarns in coarse towellings, etc.
	Rangoon	0·60	...	Up to 10s.	Twist or weft	Weak in staple, dull in colour, often stained and charged heavily with impurities.
	Kurrachee	0·90	...	28s.	Twist or weft	Moderately strong, dull and leafy.
Italian	Calabria	0·90	...	26s.–28s.	Twist or weft	Moderately strong, irregular and dull, with leaf, dirt, and short fibres.
Turkey	Levant	1·25	$\frac{1}{1200}$	36s.–40s.	Twist	Harsh, strong, and white, often nominal in market.

The above list includes nearly all the commercial cottons that are used in the trade. The lengths and diameters are perhaps as nearly correct as our knowledge of microscopy will allow at present.

Each variety of cotton is graded in dimensions, depending chiefly upon the length, which for individual grades is recognised as a standard by the Liverpool or the Manchester Cotton Brokers' Association.

Grades of cotton are defined by certain abbreviated terms or letters, which carry with them the price at which the grade or staple is selling at on a particular day. American are as follows, viz., G.O., L.M., Md., G.M., F.G.M., M.F.

Of the above six terms the first means that the staple is good ordinary, or the lowest class; the second, low middling; the third, middling; the fourth, good middling; the fifth, fully good middling; and the sixth, middling fair, or the highest class and the longest staple of American cotton officially quoted. On 14th January 1899 the above grades were quoted at $2\frac{25}{32}$d., $2\frac{21}{22}$d., $3\frac{5}{32}$d., $3\frac{11}{32}$d., $3\frac{15}{32}$d., and $3\frac{11}{16}$d.

Egyptian cottons are chiefly quoted under four or five grades, viz., Fr., G.F., F.G.F., and Gd. The first or lowest quality indicates fair staple; the second, good fair; the third, fully good fair; and the fourth, good or the best. Between the grades fully good fair and good there is often an intermediate grade adopted by the brokers, which is styled extra F.G.F., or well-up staples.

The quotation prices on the 14th January 1899 were as follows:—First, $4\frac{11}{16}$d. nominal; the latter term indicates a scarcity for a time in the market. The second grade was quoted at 5d.; third, $5\frac{1}{8}$d.; and the fourth grade, $5\frac{5}{16}$d.

East Indian cottons are more finely quoted than those from other countries, as follows:—F.F., F.G., F.G.F., Gd., F.G., Fine, S.fine. The first is fully fair; second, fully good; third, fully good fair; fourth, good; fifth, fully good; sixth, fine; seventh, superfine. The quotation prices of these cottons on the date previously mentioned were as follows (taking the Bhownuggar variety of cotton as an example):—The first grade was not quoted; the second was $2\frac{1}{2}$d. nominal; third, $2\frac{3}{8}$d. nominal; fourth, $2\frac{3}{4}$d. nominal; fifth, $2\frac{15}{16}$d. nominal; and the sixth was not quoted, so that Bhownuggar East Indian cotton was scarce in the market on the date previously mentioned.

Brazilian cottons have a fewer number of quotations in grade price than those from other countries; generally they are given as follows:—M.F., Fair, G.F.; indicating, first, middling fair; second as given; and third, good fair. The quotation prices on the date previously mentioned were, first, $3\frac{5}{16}$d.; second, $3\frac{9}{16}$d.; third, $3\frac{3}{4}$d.

The grade quotations for the Sea Islands cottons are as follows:—Ord., Com., Med., Good Med., Med., Med. Fine, Fine, Extra Fine. Briefly, the terms may be explained thus: Ordinary, Common, Medium, Good Medium, Medium, Medium Fine, Fine, and Extra Fine. The first-named is the lowest-priced staple, and the highest priced is the Extra Fine. The ruling prices of these high-classed stapled cottons on the 19th of January 1899 were quoted thus: Ordinary and Common were scarce, and no price was given in the *Cotton Brokers' Circular*; Medium, 9d.; Good Medium, $9\frac{1}{2}$d.; Medium Fine, 10d.; Fine, $11\frac{1}{2}$d; Extra Fine. 12d.

The commercial character and value of cotton fibres vary according to the country in which they are grown. Egyptian cottons are of two principal kinds, viz., the long-stapled Brown Egyptian and the white or rough Egyptian.

The long-stapled is much in demand for the spinning of stout warp yarns that are used for backing of some heavy fabrics, such as velvets, cords, and moleskins.

In Egypt there is little or no rain, but the river Nile is utilised for the purpose of irrigating the land ; it thus becomes specially suitable for the cultivation of the cotton plant. The waters of the Nile flow from the Abyssinian mountains, and convey red particles of matter from the rocks over which they flow. This tends to nourish the cotton plant, and influences the presence of the endochrome or red colouring matter in the Brown Egyptian fibres, which has the effect of strengthening the staples, which is probably due to the reddish sediment carried forward by the waters of the Nile.

In India the cotton plant is grown under adverse conditions. Up to the time of sowing the cotton seeds the ground is hard and dry.

The sowing of the seeds is dependent upon the occurrence of the monsoon or the rainy season, when the ground becomes fairly saturated with moisture. Immediately the monsoon is over the sowing begins. By the time the plant has got into full foliage and produced its inflorescence, the ground again becomes somewhat dry, and the æstivation of the flowers and the production of bolls take place at a time during which the plant is subjected to an excessivs transpiration. The flowers are developed and fertilised and the fruits are matured under a hot and blazing sun, a marked contrast to the moist climatic conditions of the American plant. The fruit of the cotton plant is the boll or capsule, and must not be confused with the seeds, as is sometimes done.

Cotton Staples.—American cotton fibres are noted for their uniformity of diameter in the body of the fibre, their snowy whiteness, and at other times for their creaminess. The regularity of length in American staples is well marked in such cottons as Memphis, Mobile, Uplands, Orleans, Texas, and Norfolks. Some other American cottons are specially noted, such as Benders, Peeler's, and Allanseed. Of the two latter classes, Peeler's is readily adapted for weft yarns that are used in raising the plush surface in cotton velvets, and for giving the latter a silky effect.

Allanseed is remarkably strong and white; it often excels in strength the staple of Benders cotton, so called from growing on the bends of rivers. When Brown Egyptian cotton is dear in price, and becomes scarce, fine spinners have found it advantageous to use Allanseed to blend with Brown Egyptian in carefully selected mixings for strong twist yarns.

Sea Islands cotton has a long, fine, and silky staple, and is used for spinning some of the finest and best of cotton yarns. The principal kinds of Sea Islands are the high-class, silky stapled varieties known in the market as Sea Islands, Florida, Tahiti Sea Islands, Fiji Sea Islands, and Queensland. These are largely used in the city of Manchester (England).

China cotton fibres, as they appear under the microscope with a one-sixth objective, have a roughened staple, and pearly-white lustre. This roughness is apparent to the fingers when pulling a staple. On the field of the microscope the fibres appear irregular in structure, the surface walls wrinkled, and the diameter of the body irregular. The spiral character is hardly uniform, and there is some tendency to kempiness in much of the staple. The length of the fibres is about half an inch.

The cotton plants producing Sea Island fibres are grown principally in the islands off Georgia, or in inland situations near the sea.

The saline constituents of the soil seem to nourish the growth of the plant, and the saline spray from the coast serves to check any tendency to excessive transpiration or dryness. This probably stimulates the growth of the plant.

Brazilian cottons are characterised for their harshness, strength, and incoherent staples. As a rule, they are not much used alone, but are often mixed with other more cohesive staples of nearly similar length, by which they are adapted to the production of medium fine counts of commercial yarns. The principal kinds are *Pernams* rough and smooth, *Peruvian* rough and smooth, *Paraïba Céara*, *Maranhams*, *Rio Grande*, and *Maceio*, with a few others. *East Indian* cottons have a short staple, and samples are often charged with impurities, such as broken bracts, the veins of leaves, sand, and leafy particles. This cotton, when clean, is white in colour, but when not clean, has a dull appearance, and is often contaminated by insect stains. At other times it is "Boll-Stained," owing to the carpels not having been gathered, and consequently becoming damp, when the inner membrane of the capsule stains the fibres a reddish or brownish colour. Boll-stained cottons are not adapted for yarns where colour is an object. They are generally quoted at a lower price on account of this discoloration.

Some kinds of East Indian cotton bolls do not open so readily, such as Scinde. Fig. 67 shows some unopened capsules. These have to be picked bodily off the plant, and a machine has been devised which separates the segments of the capsules from the seed cotton, but has now dropped into disuse. The upper part of the illustration shows some of the unginned seed cotton charged with broken bracts and portions of leaf, and on the right is a fully opened capsule with only three segments and the same number of carpels, thus showing the small amount of cotton that is contained in an East Indian capsule, in contradistinction to the amount contained in the larger capsules from other countries. For the above samples I am indebted to Mr. T. R. Marsden, of Platt Brothers & Company, Limited, Oldham.

The principal kinds of East Indian cottons are Broach, Oomrawuttee, Hingunghat, Bhownuggar, Tinnevelly, Bourbon, and Saw Ginned Dharwar and Bengals. Lower classes of staples are included under the following names, viz.: Scinde, Veraval, Comptah, Rangoon, Dhollerah, Cocoanada, and Assam.

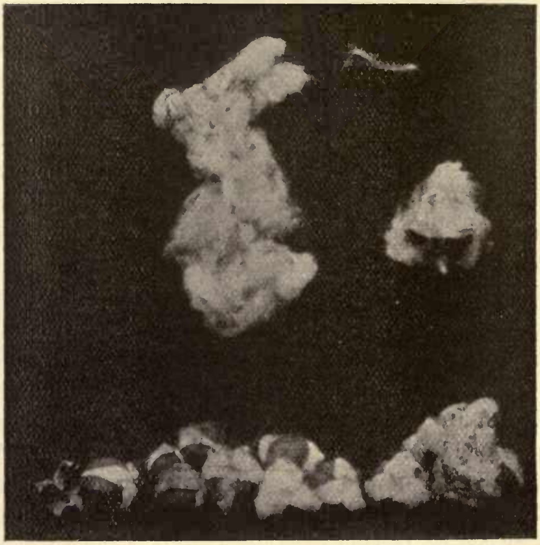

Fig. 67.—Unopened capsules.

The cotton known as *Smyrna* or *Greek* is valuable for the spinning of special hard twisted yarns.

The *West Indian* cottons are more valuable in staple than those of other countries. The principal kinds are La Guayran, Mangarole, Macedonia, and Carthagena.

Japan cottons are of short and harsh staples.

Queensland cottons are mostly grown from Sea Islands seeds.

Australia has not, so far, been successful in growing this long-stapled cotton. The want of suitable rivers in Australia and the arid atmosphere are prohibitive to cotton culture on a large scale.

Sampling.—The marketable properties of cotton fibres are tested in the raw state by putting a tuft of fibres between the fingers and thumbs of both hands and then pulling them asunder. The amount of resistance shown by the fibres as they are being pulled asunder is carefully noted, and this property and behaviour are known as the staple. Cotton brokers and buyers have by long practice become experts in the discrimination, the pulling, and valuing of cotton staples. When several staples have been pulled, they are laid on the coat sleeve of the left arm and compared. If they show an approximate uniformity of length, each is regarded as a good and reliable staple.

To ascertain the strength of a number of fibres collectively, a staple that has already been drawn as to length is held tightly between the finger and thumb of each hand, and then a sudden jerk is made and a judgment formed as to the strength of the staple. The whole of the sample from which the fibres have been taken is next lifted up to see what amount of soil or sand will drop from the cotton, on the brown paper of the parcel. This decides the amount of dead-weight impurities that the sample contains, and influences the price offered by the buyer.

The amount of leaf present in the cotton, so long as it is not too large, is not of itself so detrimental, but is regarded by the cotton buyer as a good sign, showing that the cotton has not been very roughly treated in the ginning process. If the leaf in the sample is very broad, it is surmised that there will be some difficulty experienced in scutching and cleaning the cotton in the various processes through which it has to pass before it is made into a yarn.

Neps is a term used when a number of fibres have become rolled together and entangled into a dense white opaque speck in the cotton web from a carding engine. They are often shown up prominently and are indicative of an irregular yarn.

To the naked eye they always seem to be only specks of white cotton distributed in the gossamer carded web of fibres, brought from the main cylinder by the doffer. To understand the construction of neps thoroughly, it is a good plan to place one or two under the low-power of a microscope. When a nep is on the field of the stage, it is seen to be composed of fibres that are entangled together in the centre very tightly. It is this tightly entangled centre that prevents the fibres from unravelling and these form the white opaque nep.

The exterior fibres of a nep are loosely disposed, and readily attach themselves to slivers that are being drawn or twisted.

Fig. 68 is a photo-micrograph sketch of two dense opaque neps as seen under the microscope, showing the fibres entangled with abrupt ends. The presence of neps in the yarn reduces its value commercially. In fabrics newly woven, which have to be dyed, it implies that the spinning processes have been defective. When the neps appear in raw cotton, it is often a result of defective ginning.

Gin Cut Cotton staples are distinguished by matted tufts of densely white fibres that are present in the samples. These are due to two causes: First, the masses of seed cotton have been picked before the plumose fibres have spread out, *i.e.*, before the fibres are ready for disseminating the seeds; second, the seed cotton has been cleaned from the seeds before it was ripe, as is evidenced by the matted white irregular tufts that are present in gin cut staples. These reduce the selling price in the market.

In the process of Cotton Ginning the seeds sometimes pass through the grids to the saw cylinder, or are cut by the sharp edge of the beater and the doctor knife in the roller gin. Such seeds may pass

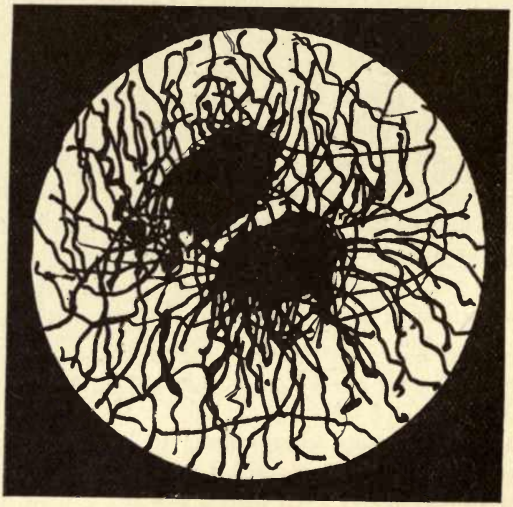

Fig. 68.—Neps (magn.).

through whole or get broken into small fragments. The fragmental portions of cotton seeds carry a tuft of attached fibres on the outer membrane; this is termed a bearded *mote*, and is regarded as an imperfection or an impurity, as it interferes with the spinning qualities of a good yarn. Bearded motes ought to be taken out in the tops and strips of the revolving flat card. The dark portion of the mote and the numerous fibres attached interfere with the good qualities of the yarn. Bearded motes are perhaps more common in Brazilian, American, and East Indian cottons. At first they are brown in colour, but turn black in the conditioning of the yarn under long exposure.

Cotton Crops.—In America the arrival of the new crop means that the masses of seed cotton have been picked from the lower branches of the plant, which is sympodial in its mode of branching. This forked system of branching facilitates the maturing of cotton bolls on the axillary branches of the plant, while the upper branches are developing leaves for assimilating purposes, and buds, flowers, and capsules at a later stage for the second crop.

The new or *Bottom Crop* of lint fibres, after they have been cleaned from the seeds, is often spoken of as being *Bloomy.* This means that the new cotton shows a glossiness of staple that is striking to the eye, making it appear to be better than it really is. The cotton broker will sometimes allow a slight reduction in the price of the cotton when the bloominess is excessive.

The *Top Crop* of cotton has the carpels plucked from the upper part of the branches of the plant, and is sometimes termed the "Second" crop. When such cotton has been ginned, it is found that the staple is hardly so good as that previously gathered from the lower or more axillary parts of the plant, where the tissues are probably richer in secretions.

Time of Crops.—The new crop of American cotton arrives in Liverpool generally about the end of September or the beginning of October. In the Brazils and in Egypt the new crop is about a month later, and the East Indian crop arrives about March.

America has a climate that is peculiarly adapted for the growth of the cotton plant. Much of the American cotton is grown on the banks of the Mississippi, the Red River, and the Brazos river of the Texas cotton-fields. The harvest of cotton is liable to killing frosts in November and December.

Brazil is a good cotton-growing country. Seeds of American cotton have been utilised to produce exotic plants which have thrived well. The cotton obtained from such plants has received the name of Santos; the staple is better adapted for weft cotton than is the general run of Brazilian cottons.

Fig. 69 is a sample of Brown Egyptian cotton heavily charged with black seeds, as shown in the illustration. Brown Egyptian has a curly appearance, which is typical of cottons that are cleaned by the roller or the Macarthy gin.

Cotton, Havre (French Cotton).—During the eighties a large quantity of cotton bales were shipped to Havre in France. It was sold at a remarkably low price, and many Lancashire spinners, particularly in Oldham, were induced to speculate in the cheap lots of French cotton, as it was sometimes styled.

The staple was short, poor, and dirty, and resulted in a considerable loss to those firms who were taken in by the new venture of buying cotton shipped through a French port, which was never a successful move to Lancashire spinners.

Boll-stained cotton consists of staples that have become disfigured by spots of colouring matter owing to the capsules becoming saturated with moisture by the rains, which causes the colouring matter from the inner membrane of the capsule to permeate the cell-wall of the fibres, and gives them the appearance of Brown Egyptian cotton, so far as colour goes. Boll-stained cottons are readily bought by some spinners, who manage to utilise them sparingly by mixing them with whiter cottons. Manufacturers who spin their own yarn often make a judicious speculation in cottons that are stained slightly. They have been spun into yarns that

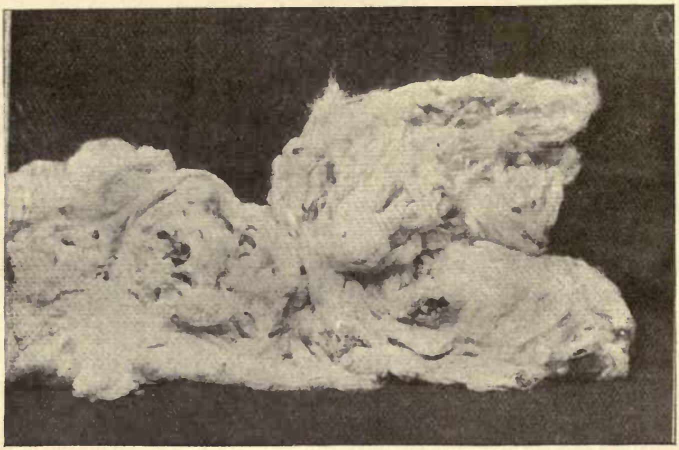

Fig. 69.—Brown Egyptian cotton heavily charged with seeds.

may be used in the weaving of Printing Cloths, also for Tangibs, Jeans, Dimities, Jacconetts, Sateens, Mulls, Tape, Checks and other similar fabrics where colour in the warp or weft is not an objection, and particularly in cloth that requires to be bleached before being used. The effect of the bleaching is to remove the boll-stained features and give the cloth a whitened appearance. Fibres of cotton that are stained are most frequently met with in those of American and of East Indian growths. The presence of stains reduces the selling prices of the cottons, and spinners who have a good reputation for the strength, colours, and structure of their yarns, carefully avoid purchasing lots or bales in which the cotton shows the least amount of staining or of discoloration whatever.

Brokers (Cotton).—Every week-day the Cotton Brokers' Association of Liverpool send out the price lists of cotton that is actually in the market, or that is expected to arrive by certain vessels which have set sail from America. Almost every private firm or spinning company has either one or more brokers upon whom they rely for their samples and for quotations of prices at which cotton can be bought.

As a rule, brokers have been trained to the buying and selling of cotton. They get accustomed to the exact length and quality of staple that will best spin the scale of counts their clients or spinners are engaged in. Certain empirical rules are laid down by the Cotton Brokers' Association, and these must be adhered to.

When a spinner or firm has given an order to the broker for a number of bales, an invoice like that given below is sometimes sent to the mill.

"Messrs. The Lancastrian Mill Co., Limited.

"Dear Sirs,—We have this day sold to you (200) Two hundred bales of Mobile cotton. *Quality middling, staple equal to sample marked B.E.N., good colour.* Shipment during latter half of 1899 by steam, at threepence one-eighth ($3\frac{1}{8}$) per lb., including cost, freight, marine insurance, and 6 per cent. allowance for bands and tare. Marine insurance shall cover 5 per cent. over nett invoice amount. Loss in weight guaranteed not to exceed 1 per cent. gross invoice against gross landing weight.

"Reimbursement by seller's or shipper's drafts at sixty days sight for invoice amount on the Lancastrian Mill Company, Limited, payable in London, with shipping documents (attached) against acceptance, or payment shall be made in exchange for shipping documents or delivery order on or (at buyer's option) before arrival of the vessel or vessels; or, failing previous arrival, not later than due date, by cash, less customary rebate for any payment. The due date of invoice shall be the seventy-fifth day after date of bill of lading, payable in Liverpool.

"Loss in weight to be ascertained by weighing on arrival at port of discharge, before sampling, due notice of weighing to be given in writing by the buyer to the seller (or his agent), each side paying their own share of weighing expenses. Allowances to be made for missing bands and ship pickings. Cotton shipped under one contract to form one weight settlement, even if shipped by more than one vessel.

"Claims for falsely packed or unmerchantable cotton shall be allowed, if properly substantiated (and accompanied with full marks and shipper's numbers), at the value of the sound cotton on the day of return, if such return be made and a claim sent in within two months from the last day of landing.

"When guaranteed equal to an American sample, a difference of $\frac{1}{16}$

per lb. to be allowed for between it and the samples of actual cotton redrawn at the port of discharge.

"Arbitration, upon shipments sold to average any particular grade, shall be settled by classing the different lots, placing grades or fractions of grades above, against grades or fractions of grades below and passing whatever part turns out, an average of the grade guaranteed, making an allowance on the remainder.

"In case of any inferiority of quality or irregularity in shipment, the cotton to be taken at an allowance, and this, or any other dispute arising out of this contract, to be settled by arbitration according to the usual terms of the Liverpool Cotton Association, Limited, without penalty. Application for arbitration with regard to quality to be made within ten days from last date of landing.

"No allowance to seller unless arbitration be demanded by the buyer, in which case the contract shall be subject to mutual allowance, etc."

Cotton Futures.—This is a system of buying cotton by contract to be available for delivery at a certain date for the spinners' use, at a price in the Cotton Brokers' lists that has been previously agreed upon. It serves as a kind of insurance to the spinner, and enables him to accept certain orders for yarn that he will be able to execute without running short of the raw material, or altering or reducing the quality and strength of the yarn he has agreed to deliver to the manufacturer. When the dealing in futures is resorted to only for actual covering of yarn contracts, it may be regarded as a legitimate system of cotton buying; but when it is only intended for speculation it often ends disastrously, and the sudden excessive losses incurred by some unfortunate limited cotton-spinning companies has been due to the system of buying futures without due consideration. Briefly stated, futures are always sold in lots of 100 bales. Each lot is provided with a docket, which is lettered; this serves as a kind of scrip or guarantee of the contract, the staple and price at which the bargain has been struck. If the cotton futures have been bought to be delivered in a month, it must then be sold at the striking price at which the futures are quoted, when the bell rings, say, at one o'clock in the day or at 4 p.m. Generally the prices are struck twice a day, and the price indicated must be paid by the buyer or the firm he represents.

Mr. Charles Stewart, Cotton Broker, of Liverpool, read a paper on "Futures" before the British Association for the Advancement of Science, on 26th September 1896, from which the following is a quotation:—"If any of you ever think it worth your while to look at a Liverpool market report in the columns of the daily or weekly press, you will find in the current number a table of abbreviations and figures, which is a copy of the diagram I placed before you. It reads thus:—

Sept., . . .	4·32½ S.	Dec.-Jan., . .	4·21½ B.
Sept.-Oct., . .	4·27 S.	Jan.-Feb., . .	4·22½ B.
Oct.-Nov., . .	4·24 B.	Feb.-Mar., . .	4·22 B.
Nov.-Dec., . .	4·22 V.	Mar.-Apr., etc., .	4·23. S.

Alongside these abbreviated months, which are called 'positions,' are figures. The first signifies pence, and the following figures so many sixty-fourth parts of a penny per pound. Thus 4·27 means 4·27/64d. A letter 'B' alongside this means buyers, and a letter 'S' sellers at the price. The letter 'V' means value of the business done and doing. What does this mean exactly? First of all, let it be understood that the standard previously referred to is the 'middling' grade of American cotton, the standard of the trade. Any cotton expert knows what 'middling' American is, just as well as any ordinary man knows what a shilling-piece is. Cotton is classed into various grades, fixed authoritatively by experts, and for which type standards exist. The ruling standard is always 'middling.' There are higher grades, there are lower grades, but the standard is fixed.

"Therefore, if a merchant sells a contract for future delivery, say in September or October, for 'middling' cotton at a given price, both seller and buyer know perfectly well what they are dealing with. Nothing else is intended, and nothing else can be substituted, except under certain conditions, and, anyhow, the basis is unaltered. It is a safe contract for both. Such contracts, however, are subject to a clause which guarantees that the seller shall not tender any cotton below the next grade lower than 'middling'—he may tender as much higher as he pleases. My hearers may reasonably observe, 'Yes, but if he tenders below the standard grade at his option, how is it fair to the buyer?' The answer is, that the buyer in this case has full resource to an arbitration on the samples of the tender, and just as much as the tender is below the standard so is he awarded by experts (subject to a right of appeal to a fixed committee) exactly such monetary compensation as the tender is below the strict contract. But observe it must be within the limit of 'low middling'; anything lower than this is rejected, and a new tender demanded or a penalty exacted. On the other hand, if the season be one in which high grades are comparatively very plentiful, the seller may tender higher than the standard, and subject to arbitration and appeal as before. Just so much as the tender is better than the standard, at the ruling prices of the day of test, does the seller receive from the buyer so much more money than the actual price of the contract. This explanation of the character of the contract carried to finality, further amplified by the remark that a seller who contracts to deliver to the buyer a September and/or October contract is bound to fulfil his engagement on or before 31st October (he may do it at his convenience upon about every alternate business day between 1st September and 31st October), or be liable to a penalty, is, however, not altogether one that explains all, for this reason: A man who buys futures does not, as a rule, want to provide the cotton."

Call Cotton.—This is a system of buying cotton, nearly similar to the buying of futures, only that a shorter period of time is allowed between the bargaining and completion of the transaction. Suppose a buyer, who calls on his cotton broker, finds the quality of staple that is adapted to spin his counts of yarn. He would like the broker to retain this quality of cotton for him, but he does not want it until that day fortnight. Thus, on a certain day in 1900 (say 21st March), futures were selling at 5·29, or 5d. twenty-nine sixty-fourths of a penny, before 1.45 p.m. A buyer, having got his quality, says to his broker: "I will give you ten on to retain me that cotton and have it ready for me fourteen days hence, when you will supply me with it at the ruling price."

If in the meantime the cotton has gone up ten points, it may count as a loss to the buyer on the transaction, but if it has gone down ten points, it is a probable gain; but all this will depend on the price quoted in the Liverpool Cotton Future prices on the day agreed upon for delivery of the cotton.

When a buyer puts five or ten points on to secure his quality of cotton, and the price runs up a good many points before the transaction is closed, he may not be in the best of moods.

This apparent loss is not always a real loss, because the buyer has secured the right quality and staple he wanted for the firm he represents, and he is assured that the quality of yarn they have orders for will be faithfully kept up. With the steady spinners, who have gained a name for their good twist and weft yarns, the quality of the cotton bought is a most potent factor for keeping up a good reputation amongst manufacturers, who like the spinner to be well covered.

Call cotton has been growing into favour for some time, and it seems to give very fair satisfaction to the buyer and the selling broker respectively.

Cotton Bales, Cylindrical.—The bales of American cotton have, for a great many years, been faulty, owing to the loose manner in which they are covered.

American cotton bales that are sent over with bad and faulty coverings are especially liable to absorb moisture in a damp atmosphere. The fire risk of these bales is increased as a result of this unfair and careless system of baling. If we compare the system of packing East Indian and Egyptian cotton with that of American, it can readily be seen that the packers in America have something to learn in placing the coverings on cotton bales. Complaints have, from time to time, been made by spinners but all to no purpose, and the impression has gained ground that either the Americans could not, or would not, study the interests of the spinners, who are their customers, and that the Americans

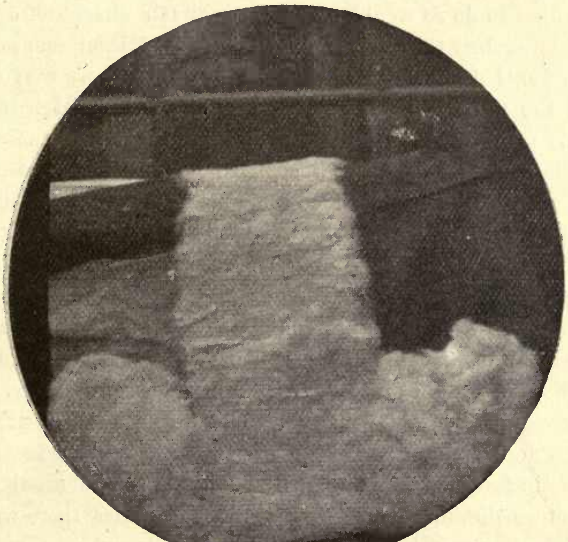

Fig. 70.—Compressed cotton.

preferred to send out badly packed bales, and that the loss to the spinners was to some extent their gain. Latterly, attempts have been made by the Americans themselves to introduce a better system altogether, a fact which does them the utmost credit. It consists in packing the cotton in cylindrical bales, a custom introduced by Mr. Edward Atkinson, of Boston, U.S.A.

Fig. 70 represents a portion of the compressed layers of cotton taken from a cylindrical bale. For this specimen I am indebted to the late Mr. John Butterworth, F.R.M.S., of Shaw, near Oldham, the well-known specialist upon cotton bales and fibres.

I photographed the example shown in fig. 70, which is a fair type of this system. In an article Mr. Butterworth wrote to the *Textile Mercury* of 1st May 1897, he says: "Some time during the month of December 1894, a Liverpool firm received a batch of 100 of these cylindrical bales, which were put on the market, and my firm bought ten bales, which we received at the mill on 9th January 1895.

"As a proof that mill men here viewed the attempted change of the form of the old American bale with considerable interest, I may state that the shipper of the above 100 bales wrote, a few days after their receipt at the mill, to ask if we would resell to him part of the ten bales we had bought, as other customers wished to try them. However, as I could see that to do so would not give us a fair chance of speaking in favour of or against this form of bale (as we had been requested by the shipper to do), I declined to sanction the resale of any part of the lot. So I had the whole lot rolled off, keeping a close watch upon them during this process. One great fault of the bales was their unwieldy length—the usual length of a Boad's bale, or in other words, nearly six feet long. I confess we only fixed a temporary apparatus to unroll them from; but such a length of a cylindrical bale would condemn it, whatever good qualities it might have in other respects. The cylindrical bale ought not to exceed the length of a Surat bale, about four feet. The average weight of the bales was about 500 lbs.; but this weight would be no objection in handling if all other faults were removed. In unrolling them I noticed nothing to object to in the appearance of the fibre. I did not see that it was in any way damaged; and I do not see why it should be, as it has to undergo quite as much pressure in its after-treatment as it would have in forming it into the bale. There was the usual amount of leaf and other dirt in the cotton; nor did I consider there was any less dust, and the loss was the usual percentage of our experience. The bales unwound all right until they got to just under one-half size, when the fleece began to unroll in a more matted state. This matting of the cotton increased as we got nearer the iron tube, forming the core of the bale, so much so that it had become hard, caked, discoloured, as if the fleece had been rolled up in a very moist state, which I fully believe had been the case, so as to form a more solid bale.

"The plan of running the production of several gins together, as shown by one of the illustrations in the article alluded to above, offers considerable facility for damping, especially in the middle part of the fleece. That excessive moisture had been used in forming the ten bales I had to deal with, I am fully convinced; all exhibited the same hard, matted character of the fleece in nearly half of the bale next the centre.

"Three or four of the bales were so matted together, besides showing discoloration and mildew, that they became unrollable, and we returned them to the shipper.

"The excessive tare is another objection to the cylindrical bale, it being over 80 per cent. in excess of the ordinary American bale. This is due to the heavy iron tube on which the fleece is rolled being much heavier than is needed.

"I like the wire binding of the bale in place of the iron hoops and loose rivets, which are a dangerous nuisance. Notwithstanding my unsatisfactory experience of the cylindrical bale, I feel convinced that it has a future before it, from a spinner's point of view, in a respect many may never have thought of," etc.

Another new system of baling that has lately come under notice is known as the "Lowry" bale. It is made up of continuous rolls of repeated layers of cotton, giving the bale a solid cylindrical shape, which is wired up to prevent it expanding, and encased in a black woven matting tied up at both ends. The bales vary in weight from 245 to 260 and 280 lbs., the latter weight at the present time being pretty general. The advantages claimed are that, in addition to a reduction in cost of freight, the bale is made up of more uniform layers, and is therefore more readily adapted for opening and cleaning purposes. A fair number of firms have adopted the Lowry bale; but it yet remains to be seen whether the new system will supersede the one that has been in use so long, or cause some other more complete system to be brought out. There is room for improvement, and spinners will welcome the fullest inquiry in order to benefit the trade.

Buying and Selling.—The terms of purchase may be shortly enumerated as follows:—

For Spot Cotton, *i.e.*, cotton which is chosen by the buyer on the cotton brokers' benches, and which the buyer has examined and satisfied himself is suitable for the counts of yarns he desires to spin, an allowance is made of 1½ per cent. discount in ten days' settlement after the date of purchase; *i.e.*, if the buyer pays for it in ten days, 1½ per cent. is allowed on the price bargained for—later than this the full price is payable.

A great deal of American cotton is purchased on C.I.F. terms, which means that a discount of 6 per cent. is allowed, which also includes the charges, insurance, and freight. In other cases the cotton is bought at a certain price, say 5d. *cum* quay charges, or 5d. *ex* quay charges, meaning that the charges accruing for storage on the quay have or have not been allowed for.

Many other terms are used to indicate the time when the cotton may be expected to arrive on the spinner's premises "Carriage paid" or "Carriage forward," etc.

The classification of cotton by the broker is a very important matter as regards both buyer and seller. Recently a case occurred where a firm was famous for the quality of the medium fine counts they were in the habit of spinning.

On one occasion the broker sent on samples to the firm, which were hurriedly approved of by one of the members, and subsequently the bales of cotton were forwarded and mixed with the other cottons in stock in the mixing-room. When the new mixing came to be used it was found that the yarn was not nearly so good as before, and owing to its lowered quality and the complaints of his customers who were taking the yarns, the spinner got tired of it. He entered an action at the Manchester Assizes againt the broker to recover the loss he had incurred in spinning the faulty yarn. The counsel for the broker contended that he had sent a particular grade of "Bourbon" cotton for the firm's consideration, and they had accepted it at the price laid down. Against this the spinner's counsel contended that the broker had made a mistake in his classification, and instead of sending a certain marked grade of Brown Egyptian, he had sent on the "Bourbon" East Indian cotton. The judge, after hearing the evidence on both sides, gave a verdict in favour of the cotton broker.

Adulteration.—In a consignment of cotton it is sometimes found that certain layers of a poorer quality are present in the bales, and that a quantity of seed cotton that has escaped the process of cleaning in the gin has been fraudulently put into the bale. In other cases some bales have become musty owing to the cotton having been packed in too damp a state, or by having water purposely poured into the cotton, during the operation of packing, in order to increase the weight of the bale. Cotton that is water-packed is liable to foster the growth of mildew, and this is probably the cause of the musty scent that sometimes emanates from such water-packed bales.

Adulteration of another kind is "sanded cotton," in which bales are increased in weight owing to the amount of sand that is present in the bales, thus increasing the amount of the dead weight.

Impurities.—The impurities present in cotton consist of seeds and portions of seeds that have been allowed to escape in the ginning process. Other impurities are the tough veins and portions of membrane of the leaves and bracts; also sand and soil. Most of these are generally got rid of in the preparatory processes of cotton spinning. If not so removed they deteriorate the selling price of the yarns.

Raw Cottons.—Fig. 71 is from a photograph of the layers of cotton from an American cotton bale. The bulky appearance is a characteristic feature of American cotton, and is a sign that it has been cleaned by the Saw Gin process, by which curliness is avoided. The longer stapled cottons are remarkable for the curly appearance in samples. Nearly all the long-stapled, and most of the East Indian cottons, are peculiar in their raw state for this curliness. It is regarded as a sign that such cottons have been ginned by the Macarthy or by one of the roller gin type of cleaners.

Fig. 72 represents two samples of cotton. In the one that has been opened the fibres have been freed from many of the impurities by the

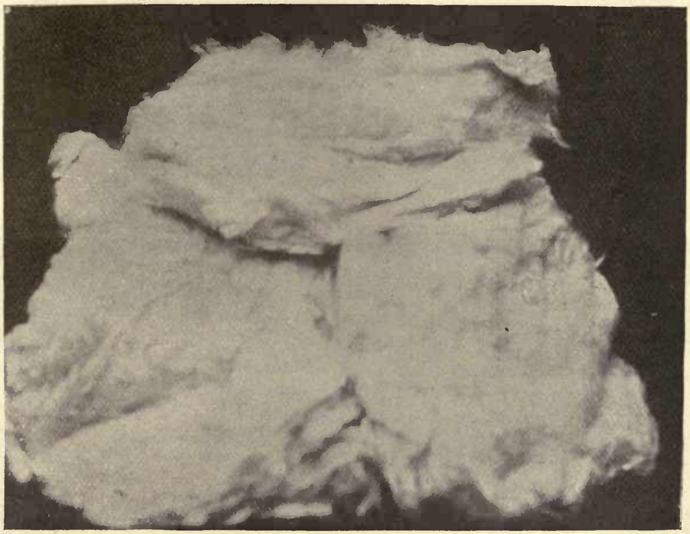

Fig. 71.—Cotton layers from an American bale.

opening treatment, and show a fleecy character. In the other, the fibres are stringy, owing to over-scutching. When cotton has been opened, it is next scutched, which means that it undergoes a further opening and cleaning process, and is then compressed into a lap sheet.

In the construction of a lap sheet it is essential that the fibres should be so disposed as to form a dense opaque lap sheet of the same thickness in every part, exactly similar to a carpet. Any variations from this character may result in the fibres behaving differently in bulk one to another, as, for instance, fig. 73, which shows a lap made from long-stapled Brown Egyptian cotton, and in which it will be seen that, while the layers of fibres adhere together, there is a jagged appearance at the sides.

When the margins of the lap sheet show this jagged character, it is regarded as a bad sign. This lap sheet has a waviness and stringy

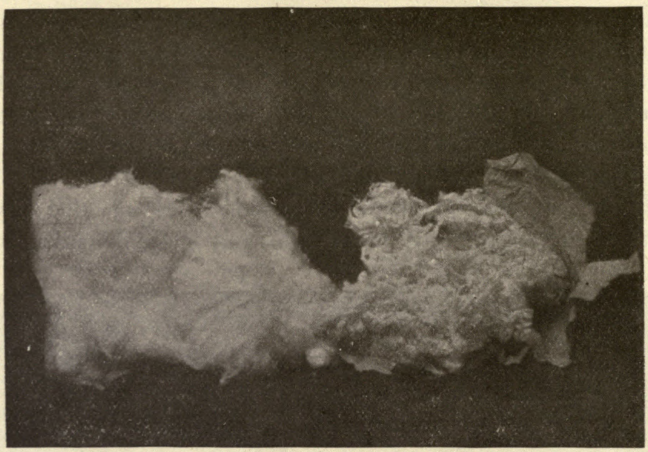

Fig. 72.—Opened and over-scutched cotton.

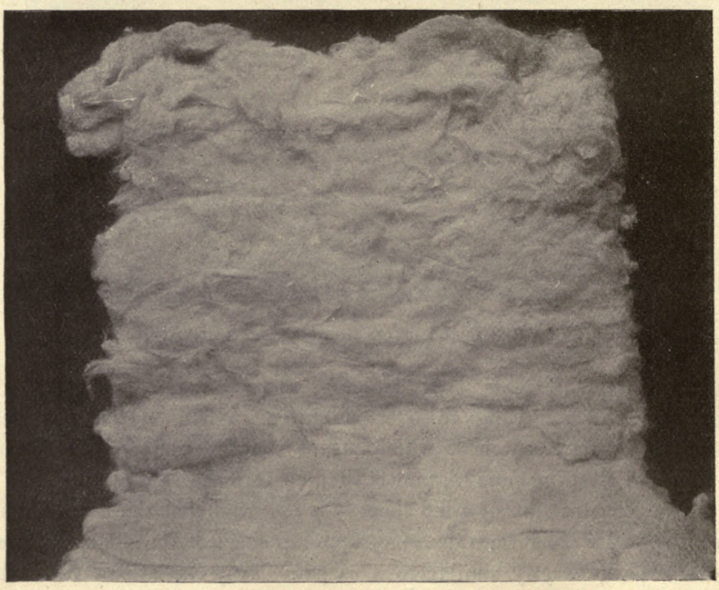

Fig. 73.—Lap of Brown Egyptian cotton.

appearance on the whole flat surface, probably owing to the fan current being run at too rapid a rate of speed; and in long-stapled cottons it is found in practice that a stringy and irregular lap sheet will readily cause neps to be formed in the carding process. Generally, if the fan current has been too strong, some of the good fibres will have been passed out with the impurities. As a rule, when this is the case, they move away from the rest of the lap in tufts which has the effect of causing a want of levelness in the lap, and in giving a semi-transparent and stringy character to certain portions of the lap that is intended to be fed to the carding engine.

The primary impurities from each of the two processes of opening and scutching are known as the *droppings.* These ought to be as

Fig. 74.—Cotton droppings.

dense as possible if the opening and scutching machines are cleaning the cotton to the best advantage, economically and financially, as then very little good cotton will pass out with the impurities, and only Pea dropping of a dense dark hue will be produced, as shown in fig. 74; but if the scutching is faulty the droppings become richer in cotton tufts, and fatty droppings are produced similar to those shown in fig. 75.

The cotton which is struck off by the beater blades of the scutcher should be removed away from the beater's course immediately; any delay at this stage may cause the fibres to become contorted into very curious shapes, and such cotton is then termed *stringy.* Stringy cotton is very difficult to work up in the subsequent processes;

it is often irregularly damaged, and cannot be made into a decent yarn, excepting for the lower counts.

Good round laps of cotton should be level at the ends, and the margins of the lap sheet entire, without any ragged selvedges.

The fibres of the lap sheet are combed or struck off by the taker-in, and carded or combed as they pass through the carding engine. When the fibres have been carded, they are combed from the doffer in a thin gauze-like web, and adhere to one another with a gossamer-like attachment, which holds the fibres together for the drawing processes.

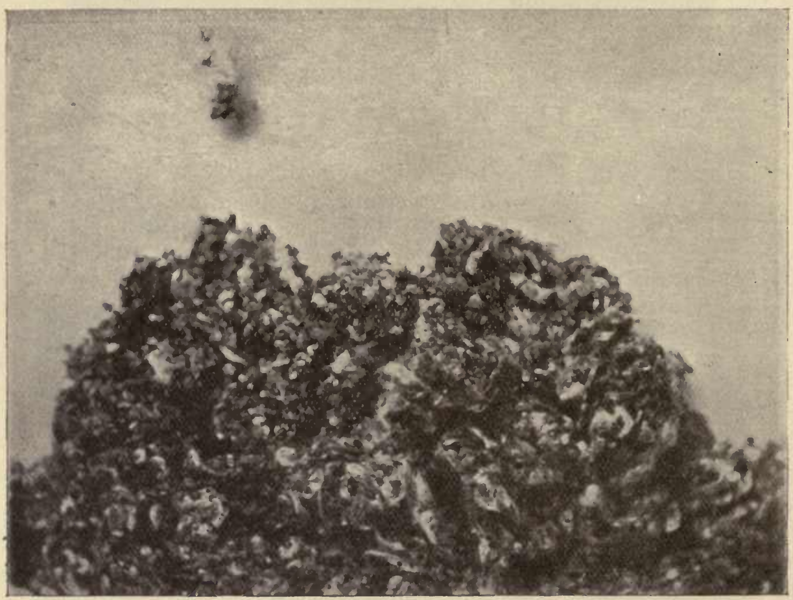

Fig. 75.—Cottony droppings (fatty).

Combed Fibres.—In the treatment of long-stapled cottons, such as Brown Egyptian and Sea Islands, that are intended to be spun into the finest of yarns, the Combing machine is brought into use. The object of combing the fibres is to eliminate the shorter fibres. The latter are not wasted, but are used for spinning coarser yarns of weft counts.

Fig. 76 is an example of combed sliver taken from the combing machine. The intermittent, shady, transverse markings are due to the reattachment of the long fibres after having undergone the combing treatment.

Fig. 77 shows a staple of long fibres drawn out from the combed sliver; there are no impurities present, and the fibres are of nearly uni-

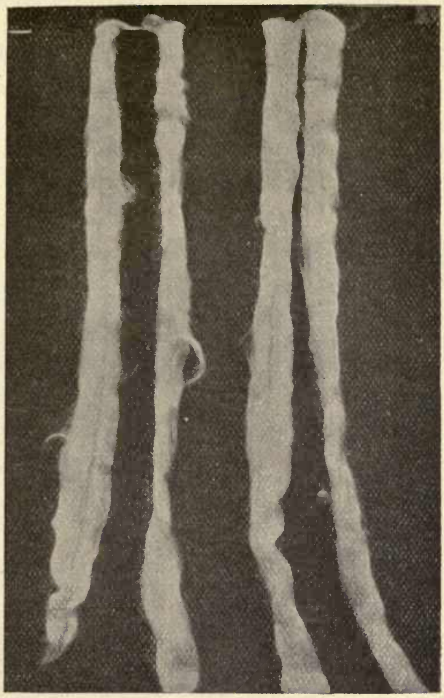

Fig. 76.—Cotton sliver (combed).

Fig. 77.—Long-stapled fibres.

form length, and lie cohesively in a nearly straight, sliver-like line, often termed parallel.

Carded Yarns.—The use of the comber is obviated when yarns of medium and medium fine counts only are required. The impurities and shorter fibres that may be present in the cotton are removed as the material passes through the various processes of hopping, opening, carding, and spinning.

Fig. 78 is an example of a good sliver from a carding engine of the revolving flat type. It has been contracted from the broad web of the card by passing through the draw-box and the coiler-box. The sliver is

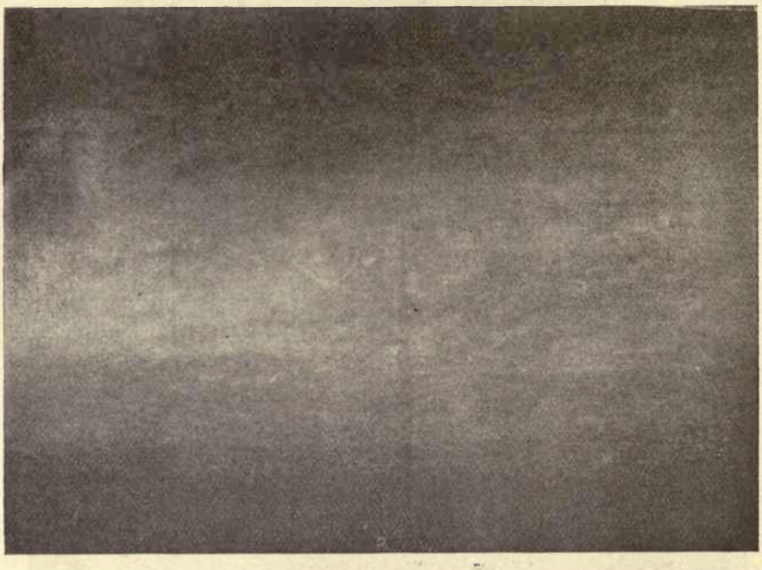

Fig. 78.—Example of a good sliver.

not uniform in thickness, and varies considerably; therefore, to avoid the irregularity, it is necessary to double them repeatedly.

The drawing sliver from the last multiple of doublings gives a sliver with the fibres arranged parallel, imbricated all in one direction in a nearly straight line. The number of doublings is generally 216 for medium counts of yarn and 512 for some of the finer counts of slivers.

The drawing sliver from the last head is fed to the slubber, and each sliver is twisted into a slubbing strand similar to those shown in fig. 79.

Fig. 80 represents the strands from the intermediate frame. Each of these strands has been unwound from an intermediate bobbin, and each is composed of two slubbing roves twisted together, and drawn out finer in the intermediate frame. The illustration shows that each one is made up of two strands of slubbing doubled together; the roundness of these strands is more regular than those of the slubbing in the previous illustration.

Fig. 81 shows the roving strands from the roving frame. If the sliver from the last head of drawings received 512 doublings, then those

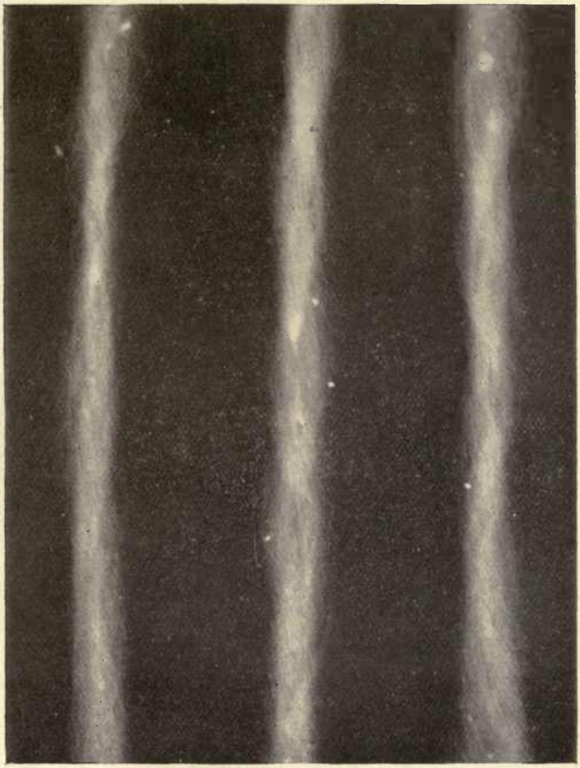

Fig. 79.—Slubbings.

at the intermediate frame would have received 1024, and the strands of rovings 2048; and if the yarn spun from these rovings is from doubled roving it means that each end or strand of yarn has received the large number of 4096 doublings and drawings. The six roving strands are remarkably level, round, and almost free from irregularities, and quite free from impurities. The yarn spun from these rovings is known in the trade as 60s. twist (brown). There is always a good demand for it, as the construction, evenness, elasticity, and strength of the yarn can be relied upon and guaranteed.

Spinning-Room.—To spin the material into yarn it is necessary to have the room heated to from 70° F. to 90° F. In fine spinning mills it mostly varies from 80° F. to 90° F. Fresh-air humidifiers have been introduced into fine spinning-rooms; these cause a current of air from outside to be passed through mushroom-shaped tubes and over heated

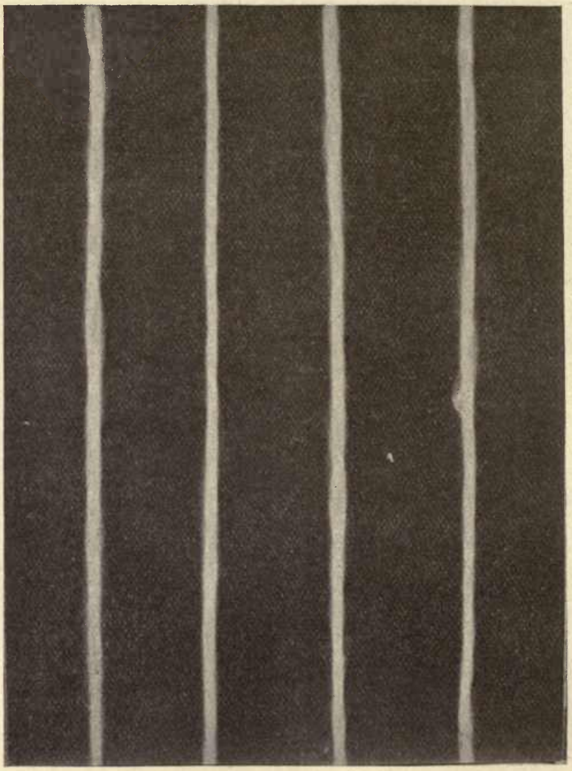

Fig. 80.—Strands of two Slubbings.

water, thus moistening the air and rendering the fibres of cotton more cohesive, and the yarn less oozy or woolly, but stronger and more elastic.

Fig. 82 shows a spinning-room and self-acting mule for weft spinning in a Preston cotton mill. The mules are run from a line shaft fixed the whole length of the room, with the drums and straps attached. The height of the room is about 14 feet. I am indebted for this photograph to Sam Gilbert, Esq., of Preston.

Yarns are of at least two well-marked kinds, viz., twist and weft. Twist yarns must be strong, round, and elastic when stretched out in the fingers of both hands; they form the great bulk of the warp threads used in cotton cloth manufacture. Weft is spun from softer staples of cotton than twist. The staples are of a good colour, either white or brown, as the yarn is required to intersect the warp threads and then float over an interspace of

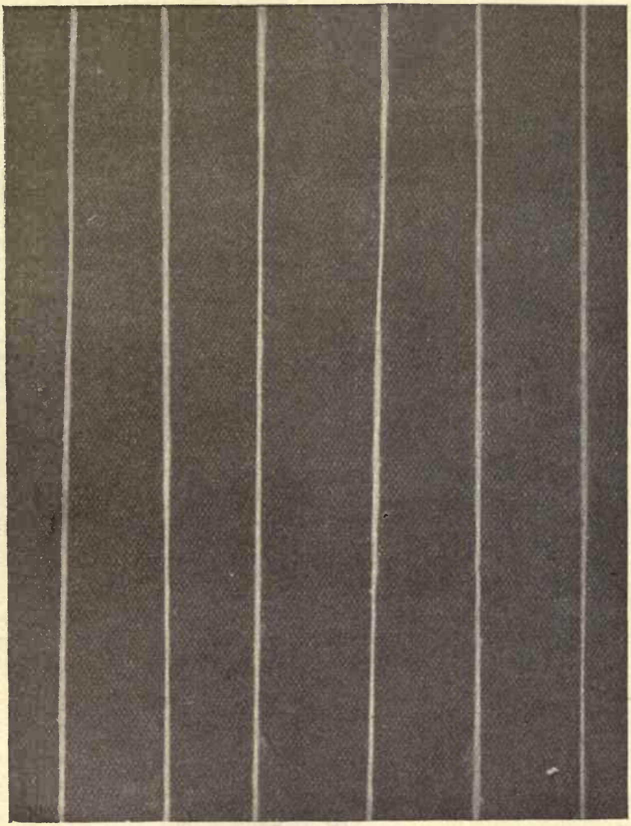

Fig. 81.—Roving strands.

other warp threads. The weft thus gives a good face to a cloth, or it gives and takes with the warp, and intersects every thread as the strand of weft yarn is conveyed in the vehicle of cop yarn in the shuttle, which leaves behind a portion of endless weft on the trash board. This is pushed up to the woven cloth by the reed fixed in the sley, and controlled by the rocking-shaft and crank-arms of the power-loom.

Cotton fibres in a raw state are reputed to possess from 300 to 500 twists per inch. The accuracy of these numbers may be open to question; nevertheless, the spiral twists are numerous. These spiral twists are the important characteristics of cotton fibres, as they cause them to cohere together, and so render them capable of being doubled, drawn out, and doubled repeatedly, and ultimately of being twisted up collectively into the spiral strand that is known in the trade as *Yarn*.

Yarns having distinct characters and names may be regarded as species; while those which differ from a given count, or which are spun for a

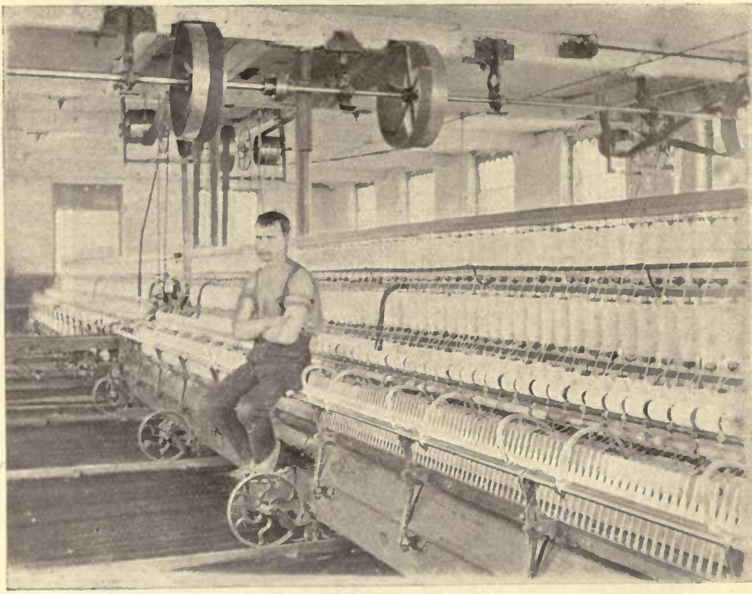

Fig. 82.—Spinning-room and self-acting mule.

particular kind of cloth for which there is only a temporary demand, may be ranked as varieties. The principal species of yarns are crotchet, lace, water twist, hosiery, bump, mercerised, hard and soft twists, crape yarn, spotted twist, knickerbocker, wig, water twist, and merino yarns, samples of which, in the form of cops, are always on sale by the "yarn agents" on the Manchester Exchange.

Cotton Dyeing.—Cotton is sometimes dyed in the raw state for the use of the spinner who makes a speciality of spinning dyed yarns. This applies mostly to weft. Sometimes a good black weft is a desideratum by the manufacturer who does not want the yarn dyed in the cop. In the latter case a variation of colour may occur in some parts of the cop, and this will interfere with the colour-pattern of the woven fabric; but when the cotton is dyed in the raw state there is a better chance of the spinner producing a weft yarn of a jet-black colour. The iridescent or rainbow yarns and cotton merino yarns are produced by different coloured rovings being doubled in the fly frames. Pepper-and-salt coloured yarns are made up similarly; while those of red, purple, blue, and yellow are produced from a mixture of single coloured cottons.

In twist yarns used in the coloured goods trade, there is a greater variety of colours used for dyeing the warp yarn; but in this case the yarn is first produced in the grey state in the form of twist or bastard cops, after which the yarn from the cops is reeled into hanks, which are then sent to the dyer. When the yarns have been dyed, they are

Fig. 83.—A weft skipful of cops.

sent back to the firm in the hanks. The latter are placed on bird-cage bobbins, from which the yarn is conducted upon barrel-shaped bobbins, which are afterwards used by the coloured warper attendant.

These specially coloured yarns differ in their treatment from the ordinary warp yarns in that they are not passed through hot size. Whatever sizing they may undergo requires to be done very carefully. An immersion of the coloured yarns in hot size would cause a bleeding effect, and the colour would run into other yarns. The coloured section of the cotton trade is a very important and special industry, as it requires the use of looms with revolving and changing shuttle-boxes, specially adapted for keeping the different colours of the pattern true during the intersection of the warp and weft threads.

Yarns, Cops, Ornamental Yarns.—Fig. 83 is a weft skipful of cops just doffed from the spindles. The base of each cop is protected by a paper tube resembling a cigar-holder. The presence of the tube is some guarantee that the cop is soundly built, and that only a small amount of waste will be made in the weaving of the cops. The apex of the cop is the *nose* or *chase*; this extends from the shoulder of the cop to its apex. The shoulder acts as a good support to the chase of the cop in winding.

Fig. 84 is a fancy doubled yarn combined together. One strand of these yarns has been tightly twisted, and the other has not only been spun softer, but delivered from the rollers in a more loose manner. The harder twisted yarn serves as a core around which the softer

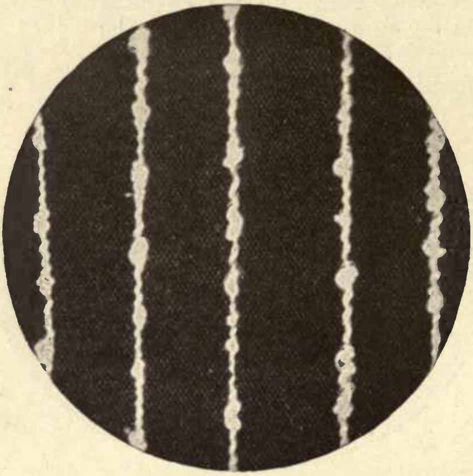

Fig. 84.—A fancy doubled yarn.

twist is wound. The delivery of the softer yarn has been intermittent at intervals, and run up into congested and spiral loops, which have been termed *knops*. These fancy combination yarns were at one time confined to the woollen trade of spinning and doubling, but for some years it has been customary to spin them from cotton yarns alone. They are chiefly used to produce figured or raised effects in fancy dress goods, toilet goods, and towellings, as also the snowstorm effects of woollen goods. There are many distinct varieties, and the demand for these fluctuates with fashion, good or bad trade, and other causes.

The ornamenting of weft yarns by an intermittent colouring is sometimes resorted to without doubling.

Fig. 85 is an example of the ordinary white weft yarn when it was spun. It has since undergone some special treatment to give it the effect which is seen in these figurative yarns. The yarn, when stretched, has been pressed upon with a black colouring matter at

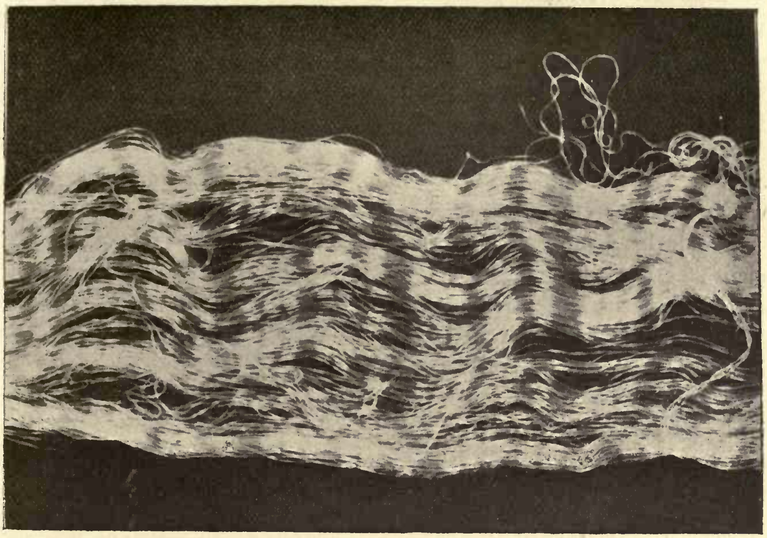

Fig. 85.—Ordinary white weft yarn (spotted).

regular intervals. Any other colouring matter than black can be used. These are known as "spotted" yarns.

PAPER FIBRE PLANTS.

The vegetable kingdom has been keenly searched for fibres that could be utilised in the manufacture of paper. The Egyptians were early in the field of discovery, and used the cellular tissue of the *Papyrus antiquorum* of the Nile for writing on. Many British fibrous plants are suitable for paper-making; those of other countries have generally been preferred for this purpose.

The following are the principal plants that have been used for paper-making:—

The **Common Reed** (*Phragmites communis*), the stalks of which are prepared by immersing them in a solution of boracic acid, and afterwards removing the acid by washing.

Cotton Plant.—The "bark," after separation from the stalks by crushing, is carded and heckled. In addition to being used for paper, the fibres have been spun into threads, twine, cordage, ropes, wadding,

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and used for stuffing horse-collars, pillows, chairs, and also for caulking ships.

Bamboo.—A kind of paper has been made from the stems, after undergoing a degumming operation.

Seaweeds.— The broad-fronded *Laminaria saccharina* has been especially used in the making of paper, papier-maché, and boards, under the name of *Algin.*

Blue Moor Grass (*Molinia cærulea*).—A paper is made from it after it has been converted into pulp. This grass is common in marshy woods, where it forms very large hassocks.

Liquorice Root (*Glycyrrhiza glabra*, Leguminosæ).—The root of this plant has been recommended for the making of pulp for both white and brown paper, as also for millboard. The plant is much cultivated for its mucilaginous properties, and is used in medicine. Pontefract, in the West Riding of Yorkshire, is a famous place for its culture.

Twitch or **Couch Grass** (*Triticum repens*, Gramineæ).—This grass is a pest to the agriculturist and the gardener, as its creeping rhizomes are difficult to extirpate. It has been mixed with cocoanut fibre and tan for the making of pulp to be used in paper-making.

Indian Corn (*Zea Mays*, Gramineæ).—This exotic cereal has received some attention for the making of paper pulp or half stuff.

Hop Plant (*Humulus Lupulus*, Cannabinaceæ).—The wild hop grows plentifully in the country waysides and ditches of the south of England, particularly near the Thames about Staines (Middlesex). The fibres of the roots and of the climbing stems of this plant have been recommended for use in paper-making; also for threads, cords, fabrics, and felt.

Grass Wrack (*Zostera marina*, Naiadaceæ).—This is a grass-like plant found growing in salt-water ditches near the sea-shore, and on rocks between tide-marks, and is fairly common. The leaves are linear without points, but sheathing at the insertion. It has been singled out as a likely plant for paper-making, either alone or in combination with other fibrous materials under the name of *Alva.* It has been used by upholsterers. Beds have been made of it in Iceland and the north of Europe. The leaves of it have been used for the packing of glass bottles, etc.

Horse Radish (*Cochlearia Armoracia*, Cruciferæ).—The fibres of the leaves and stems of this British cruciferous plant have been used for making paper.

French Willow-Herb (*Epilobium angustifolium*, Onagraceæ).—This plant grows in moist places on the banks of rivers, ponds, and ditches in Scotland, and more sparingly in England. The bark of the stems has been used for paper pulp, and the fibres, after heckling, for yarns similar to those of flax and hemp.

Mallow, Common (*Malva sylvestris*, Malvaceæ).—The fibres of the roots and stems of this British plant, after undergoing the several processes of crushing, boiling, stripping, washing, and squeezing, have been utilised for paper-making purposes.

Arrow Head (*Sagittaria sagittifolia*, Alismaceæ).—This is a British aquatic plant that grows in rivers, ponds, and canals. The plant is a Monocotyledon. The fibrous material in the leaves has been used for paper-making. The plant is hardly common enough to become of general use, and its distribution is somewhat local.

Goat's Rue (*Galega orientalis*, Leguminosæ).—This is a leguminous plant, a native of the Levant, introduced into England as an ornamental plant in 1801. The stem, leaves, and root have been utilised for the making of paper pulp. Another species, *G. officinalis*, has also been used.

Flax and **Hemp** plants have both been employed in paper-making to some extent, but as they are much better known as cordage plants, they are described in an earlier section.

Numerous foreign plants have attracted the attention of the paper-maker, one of the most important being *Stipa tenacissima*, or the esparto grass or halfa—a well-known grass indigenous to North America, Spain, and Northern Africa.

Straw has been used in paper-making, but is rather difficult to manage, owing to the numerous nodes in the stem and the cost of bleaching.

Spruce Fir and wood obtained from the **Pine** stems are much used for paper-making. The wood of spruce (*Abies*) is the easier to work up; it has a smaller number of resin canals than those of the pine, and perhaps fewer nodes.

The **Aspen** (*Populus tremula*) and the **Lime** (*Tilia*) give a good white pulp. **Birch** (*Betula alba*) and **Beech** (*Fagus sylvatica*) are sometimes cut up for wood pulp. Machines have been made that are capable of turning out 2500 square yards of paper per hour.

Banana Fibre or **Adam's Apple** (*Musa sapientum*, Musaceæ).—This plant is a native of the West Indies. It differs from the Plantain tree in having its stalks marked with dark purple spots and stripes; it has also a shorter and a rounder fruit.

The fibres are fine and repeatedly crossed and intersected, resembling a mock leno fabric.

Fig. 86 is an example of the naturally woven fibres of the banana. It has been used for paper-making, and by the natives of the West Indies for the weaving of bags. The large shuttles used in the weaving of the fibres of *Musa sapientum* are shown in one of the cases of No. 2 Museum at Kew. The shuttles and implements are large, rude structures, but serve to show what man can do in cases of necessity. Bags are made of the fibres, and are used for the carriage of Betel nuts. Into these fibres the warp yarn is interlaced, forming a gauze-like material with an ornamental fringe on the margin.

Garments have been made of banana fibre ornamented with the leaves of the Pandanus or Screw pine.

Sleeping mats and packages for holding the dried bananas have also been made from portions of the plant. The leaves of the banana are

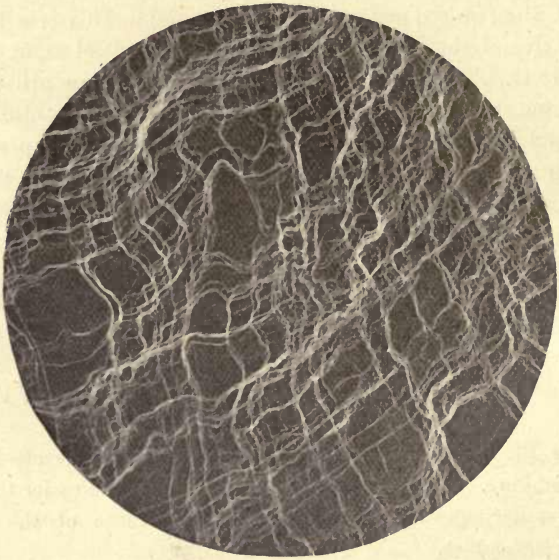

Fig. 86.—Banana fibres.

oblong, obtuse, entire, of a moderately thick, leather-like texture and pinnate venation.

The spikes of fruit weigh from ten to forty pounds. It was introduced into England in 1729. The banana has been used together with rags by Mr. T. Routledge for the making of paper.

Bhabur Grass (*Ischæmum angustifolium*, Gramineæ).—A native of India, which, with other species of the genus, was formerly included amongst useless grasses. As a paper-making fibre plant it has received some attention. It is also used for cordage purposes and mat-making. Mr. John R. Jackson says of this plant: "This is one of the best substitutes for esparto that has yet been introduced. Since 1878, when trials were made in this country with the grass as a paper material, it has become very largely used in India."

Bodolee Sutta (*Pederia fœtida*).—A native of India, where it grows profusely in the jungles and on the banks of the Brahmaputra river. Like most dicotyledonous plants the stem is conspicuous for the nodes, which occur at intervals of 10 to 24 inches.

The process of obtaining the fibre has been described by a writer in Spon's *Encyclopædia* as follows :—

"The cut stems, while still green, are divided at the joints, and the fibre is removed in the following way :—The operator takes each section in both hands, and twists it as much as possible, to disengage the fibres, having first carefully stripped off all the bark of the stem. He then disengages at one end enough of the fibre to take hold of, and gradually strips it entirely away. The process would be too slow, laborious, and costly for commercial purposes. Machinery has not yet been applied to it. Probably a pair of crushing rollers and a simple scutching apparatus would suffice. The fibre is possessed of great strength and flexibility, and has a silk-like appearance; it seems to be adapted to the finest textile purposes in spite of its shortness as governed by the length of the sections. Samples of the fibre, exposed for two hours to steam under a pressure of two atmospheres, then boiled for three hours, and again steamed for four hours, lost only 4·26 per cent. by weight, thus showing its durability."

Canada Rice (*Zizania aquatica*, Gramineæ).—This plant is a native of North America. The stems and leaves, which contain only a small amount of silica, have been used for paper-making purposes, for which they are well adapted. The seeds of the plant are farinaceous, and the plant was formerly grown on the margins of ponds in Middlesex, and Ross-shire in Scotland, for poultry feeding. The plant is an annual, and grows plentifully on the banks of Lake Erie, in the swampy districts.

Chinese Coir Palm (*Trachycarpus excelsa*, Palmaceæ).—The leaves are large and fan-like. Fig. 87 is a photograph of a plant which was growing in the open air at the Royal Gardens, Kew, in 1898.

The leaves serve as a kind of macintosh, and are used also for sun-hats, mantles, and bags. Brushes, brooms, and mosquito whisks have been made from parts of this noble palm.

Many of these articles are to be seen in No. 2 Museum at the Royal Gardens, Kew; also brooms made from the bases of the leaves grown in the grounds.

Colorado Hemp (*Apocynum cannabinum*, Apocynaceæ).—A native of North America. Loudon says: "From the stalks of *Apocynum* *cannabinum* the Indians of North America prepare a substitute for hemp, of which they make twine, bags, fishing-nets and lines, and linen for their own wear."

The fibre obtained from the plant is long, of considerable strength, and very elastic; it has been utilised for the making of paper. It is easily bleached, and has an affinity for dyes.

Cotton Grass (*Eriophorum latifolium* (Hoppe), Cyperaceæ).—A

Fig. 87.—Chinese Coir Palm.

grass-like sedge, found growing plentifully on the bogs and marshy districts of the hilly districts of England. The downy bristles are plumose appendages to the ovaries. Some attempts have been made to utilise the bristles or so-called fibres of the cotton grass in the spinning of cotton yarns, but without success.

Fig. 88 shows the characteristic feature of the fibres, which are not spirally twisted; hence their unfitness for spinning into yarn. The same remark applies to the single or woolly-headed cotton-grass, which grows very commonly in similar districts to *E. latifolium.*

Some examples of paper and of cloth made from the cotton grass are to be seen in No. 2 Museum, Royal Gardens, Kew.

Fig. 89 shows the single-headed species. The latter is known as the Hare's Tail Cotton Grass. Both the many-headed and the single-headed have been tried for the making of paper, papier-maché, and millboard. The fibres have been mixed with *Bryum ventricosum* (Swelling Thread Moss). They are first boiled in river water for about two hours, or in an alkaline solution for about one hour. The material requires agitating and washing, and may afterwards be rendered into pulp.

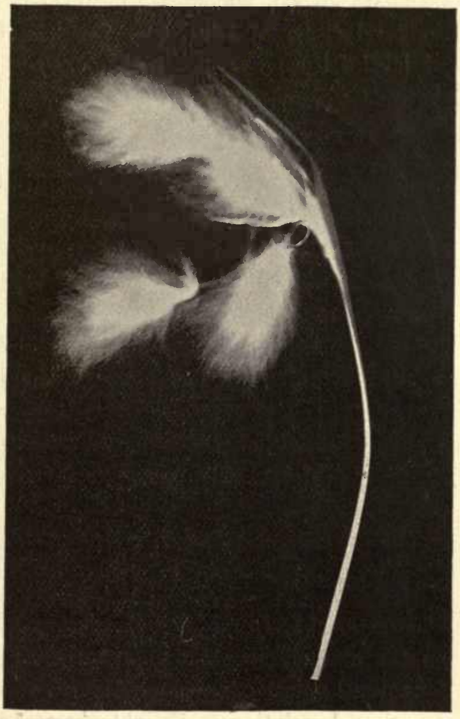

Fig. 88.—Cotton Grass (many-headed).

Esparto or **Halfa** (*Stipa tenacissima*, Gramineæ).—This is a species of Feather grass which grows wild in Tripoli and Northern Africa, and has now become well known as a paper-producing grass plant.

It takes three years to make the hassocks of leaves of the plant good enough for paper - making. An authority on the process, referring to the fibres of this grass, writes: "They felt readily, and yield an excellent pulp, which is extensively used alone, or mixed with rags, wood pulp, or straw. They furnish a paper which is pliant, resistant, transparent, and of great purity; thicker than other papers of the same weight, and forming a good printing and writing substance. The falling away in the use of esparto for paper-making, and the substitution of cheap paper pulps, must therefore be regarded as likely to lower the general quality of English-made paper."

Notwithstanding the above gloomy remarks, Esparto still claims attention. In the *Monthly Circular* of Messrs. Ide & Christie, of London, dated 15th April 1899, Esparto is reported on as follows:—"The very limited demand and dull tone recorded in our last issue have continued, if indeed they have not become intensified, during the past few weeks. Buyers and sellers alike have shown a disinclination to consider new business of any magnitude, and as a result the volume of actual transactions has been small and uninteresting. The heavy receipts of the first two months of the year were followed in March by a very moderate arrival, which was insufficient to bring the quarter's total to the level either of 1897 or 1898. The falling off, however, was slight, while the twelve months' receipts, although below those of the corresponding period of last year, are considerably over those of 1897. Imports, so far as recorded, of the current month have been full, and although these are almost wholly passing away from ship's side on pre-existing contracts, they tend, as usual with full deliveries, to restrict the consideration of new business for even distant fulfilment. There is little or no change in current quotation of prices, but those for new crop Spanish shipments are reported slightly lower, without evoking much response from buyers. African sellers are somewhat reticent as to the future, and do not press offers of distant contracts on the market, since the unfavourable prospects of supplies from Tunis for several months to come may cause consumers' attention to be directed to other descriptions. Freights have been steady, at moderate rates, from all Esparto ports, but there is no excessive supply of steam tonnage being offered homewards."

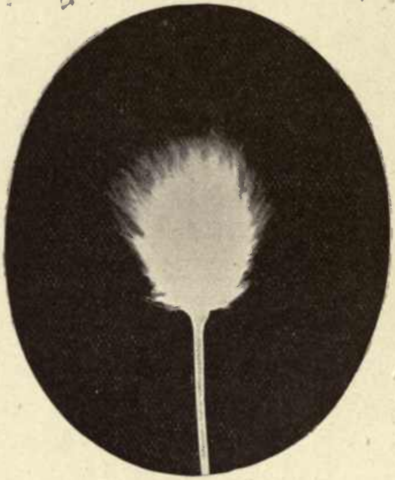

Fig. 89.—Hare's Tail Cotton Grass.

The principal kinds of Esparto grass are classified under the names of Spanish, Algerian, Tunisian, and Tripoli. The average current prices for the best Spanish Esparto on the 15th April 1899 were quoted at £4, 10s. to £5, 10s. per ton. The total imports of Esparto and other vegetable fibre for paper-making for twelve months ending March 1899 reached 195,725 tons.

Elephant Grass or **Reed Mace** (*Typha elephantina*, Typhaceæ).—The culms of this plant and of other kinds, viz., the broad-leaved and narrow-leaved Cat's Tail or Reed Mace, are used for making mats, and the fuscous, downy covering of the ovaries are used for stuffing pillows. Loudon says: "The leaves are frequently used for making mats, baskets, chair-bottoms, and sometimes for thatch."

Fig. 90 is the downy plumose covering of the ovaries of *Typha latifolia.* As stated above, it is adapted for stuffing pillows. The flossy down has been used for making Rice and China papers.

Eryngo Fibres (*Eryngium,* Umbelliferæ).—An exotic species of Eryngium or Sea Holly has received some attention for paper-making. The leaves of the plant are the members which have been used, having been introduced from the Argentine Republic. The exact species that has

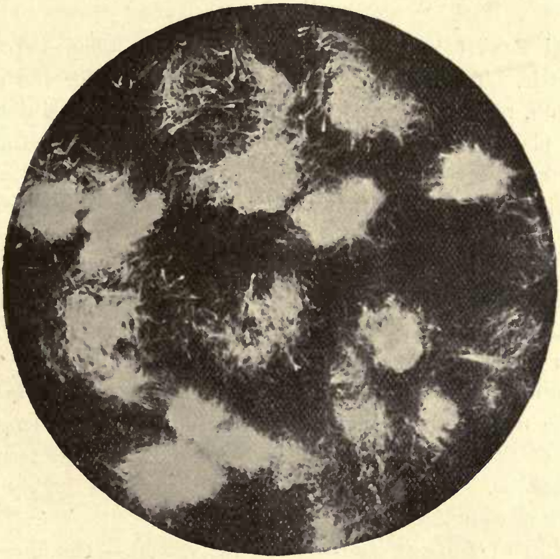

Fig. 90.—Downy ovaries of *Typha latifolia.*

been used for the purpose does not appear to be well ascertained, neither is the quantity obtainable quite clear. Almost all the species of Sea Holly are remarkable for their stiff stems, spinose leaves, and umbellate flowers. They are mostly sea-shore plants, and are types of the Natural Order *Umbelliferæ.*

Fireweed (*Erecthites hieracifolia,* Compositæ).—The fibres obtained from this plant are the plumose appendages of the fruits, and have been used for cordage and for paper-making. The fibres being loosely attached to the fruits, are easily separated, thus obviating the necessity of much cleaning. The fibres are said to be very strong, and well adapted for paper-making.

The Fireweed plant is really a *Senecio* or Groundsel, annual in duration. It is a native of North America, and is the pest groundsel of newly cleared ground, just as the common groundsel is in England. The plant grows a height of 1½ feet, its stems are twiggy or virgate, and the leaves deeply toothed.

Hibiscus (Lime Tree Leaved) (*Hibiscus tiliaceus*, Malvaceæ).—This plant is a native of the East Indies, and was introduced into England about 1730 as an interesting plant of the Mallow family. The habit of the plant is bushy, and the bast fibres are easily separated from the other tissues of the stem. In Bengal the fibre is known as "Bola." It has been used as cordage, but is said to be better adapted for paper-making purposes.

Mamaki Bast (*Pepturus albidus*, Urticaceæ).—The Pepturus is a kind of nettle. The bast fibres of the stem are used for the making of a native cloth, resembling that prepared from the Paper Mulberry plant. The latter plant may be seen growing in the Water Lily House in the Royal Gardens, Kew. It resembles at first sight an *Equisetum* of a large type, with pendant, terminal branches. The plant is an aquatic.

Maize or **Indian Corn** (*Zea Mays*, Gramineæ).—This plant is extensively cultivated in India, but its first introduction was from America in 1562. As a monocotyledonous plant the fibro-vascular bundles are scattered in the ground tissue of the culm or stem.

The fibro-vascular bundles have a clear length of six inches to a foot between the nodes, the actual length depending on the length of the internodes of the stem. The fibrous bundles have been recommended for paper-making. The fruit of maize constitutes the highly nutritious Indian Corn of commerce.

Musk Okro (*Hibiscus Abelmoschus*, Malvaceæ).—The fibres obtained from the stem of this plant are from 3 to 5 feet in length. They are strong, silky, and pliable, and have been used for paper-making.

The kind of paper known as *Bonda*, which is said to be almost equal to that made from rags, is made from these fibres.

In the research department of the Imperial Institute, Cromwell Road, London, an analysis of the Musk Okra fibres has been made, with the following result:—

"The plant in flower was steeped for ten days, and the fibres then examined. Result: Percentage of moisture, 9·7. Ash, 1·4. Hydrolysis loss, *a* 10·4, *b* 17. Mercerising loss, 19·9. Nitration gain, 39·8. Cellulose, 78·7. Length of ultimate fibre, 3·0 to 4·5." The fibres are stated to be free from reticulation, etc.

The Musk Okro plant is a native of India. The seeds are large and of a musky odour, and have been used as a substitute for animal musk for scenting powders and pomatums in toilets, etc.

Needle Palm (*Yucca brevifolia*, Liliaceæ).—The leaves of this plant have been utilised for paper-making. Its stem has been called the Boss Tree protector, against rabbits.

The plant is a native of South Utah. Specimens of paper made from its leaves have been presented to the Kew Museum by T. Routledge, Esq.

Nepal Paper (*Daphne cannabina*, Thymelaceæ).—The famous Nepal paper is produced from this plant and a species of another genus, *Edgeworthia Gardneri*.

Sir J. D. Hooker, in his *Himalayan Journals*, says: "Most of the paper used in Tibet is, as I have elsewhere noticed, made from the bark of various species of *Daphne*, and especially of *Edgeworthia Gardneri*; is imported from Nepal and Bhotan; but the Tibetians, as MM. Huc and Gabet correctly state, manufacture a paper from the root of a small shrub. This I have seen, and it is of a much thicker texture and more durable than Daphne paper. Dr. Thomson informs me that a species of *Astragalus* (Milk Vetch) is used in Western Tibet for this purpose, the whole shrub, which is dwarf, being reduced to pulp."

Nipa or **Molucca Palm** (*Nipa fruticans*, Palmaceæ).—The pinnate leaves of this fine palm have been much used for thatching houses, for mat-making, and for the coverings of cigarettes. The plant is a native of the East Indies. It has been recommended for paper-making.

Sir J. D. Hooker, in his *Himalayan Journals*, mentions this palm as follows:—"Receding from the Megna, the water became salter, and *Nipa fruticans* appeared, throwing up pale yellow-green tufts of feathery leaves, from a short, thick, creeping stem, and bearing at the base of the leaves its great head of nuts, of which millions were floating upon the waters, and vegetating in the mud."

Paper Mulberry or **Tapa Cloth** (*Broussonetia papyrifera*, Vent., Moraceæ).—The inner bark of this plant is used for the manufacture of some strong and special kinds of paper. The bast tissue, when stripped and washed, is white, and bears some resemblance to a fabric. It is known as Tapa cloth.

In China and Japan the plant is cultivated much as osier plants are in England. In the processes of manufacture, the bark, after being separated from the plant, is steeped in water till the inner and outer layers can be separated from each other. The new or most internal bark is the best, and is used for the manufacture.

The finest white cloth, worn by the people of Otaheite and in the Sandwich Islands, is made of this tree. Fig. 91 shows the bast tissue of the *Broussonetia papyrifera* slightly magnified. The fibres are white, irregularly reticulate, with wide and narrow interspaces.

Dr. Chisholm, speaking of the qualities of this plant for paper-making, says: "The strength of this paper is due to the fact that in making the pulp the large bast cells are not broken and torn as in European pulping machines, but merely softened and separated by beating. In taking up the pulp in the mould, the cells are made to lie in one direction, and the pulp may be strengthened by taking one or more additional dips in which the cells are made to lie in other directions.

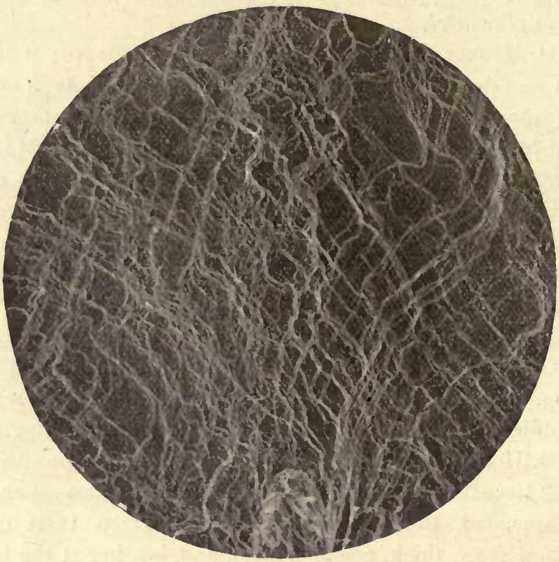

Fig. 91.—Bast tissues of the Paper Mulberry.

Gums are used to make the cells of the pulp adhere. Thick papers are made, capable of being used for many of the purposes of leather."

The material obtained from this species of plant is also known as Rice Paper or Tetroplanax. The plant belongs to a branch of the *Urticaceæ* or Nettle family, and is a native of Japan.

Papyrus (*Papyrus antiquorum*, Lk., Cyperaceæ).—The soft cellular tissue of this plant was at one time much used as a paper by the Egyptians, under the name of papyrus. It was made in sheets by pressure, and held in high repute for its durability.

The plant grows in the calishes or swamps of the river Nile. The stem is tall, growing to a height of ten feet from a horizontal, thick rootstock. The leaves are ensiform, and of a greenish-brown colour.

The stem bears at its summit an umbel or tuft of reflexed, filamentous, leaf-like branches upon which the inflorescence is developed.

This plant has been styled the Bulrush of the Nile. In addition to its use as a paper, it has been utilised for making cordage, boats, and mats.

Fig. 92 shows three stems bearing the umbellate filamentous tuft of branches in an actively growing state in the Water Lily House at the Royal Gardens, Kew.

Poker Plant Fibres (*Tritoma Uvaria*, Liliaceæ).—A native of the Cape of Good Hope. It is cultivated in England as an ornamental plant, but abroad it is also sought after for the sake of its fibre.

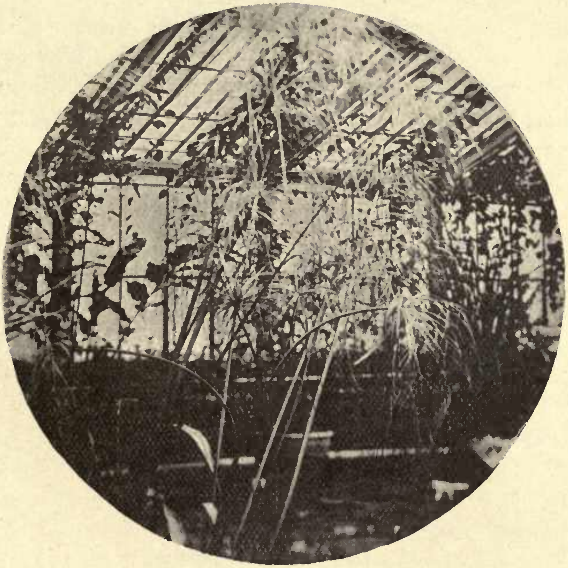

Fig. 92.—Papyrus plant.

The leaves of the plant are softened under pressure in hot water, after which the fibres are easily separated. Another species, *T. recurvata*, is also utilised for its fibre as a paper-pulp producing plant.

Fig. 93 is an illustration of a group of Tritomas flowering in the Royal Gardens, Kew, August 1898. The illustration shows the leaves and flowering stalks in contradistinction one to another.

Porcupine Grass (*Festuca* or *Triodia irritans*, Gramineæ).—A common Fescue grass which grows abundantly in the waste tracts of Australia. It has been used for paper-making.

Prairie Grass (*Spartina cynosuroides*, Gramineæ).—This grass is a native of North America. The leaves have a tough texture, and are long, flat, and glaucous. This grass is said to be almost equal to Esparto as a paper-making material. This grass has been utilised by the Spaniards for the manufacture of cordage and ropes. The plant grows in the swampy parts of North America.

Spartina juncea is another species that abounds in the salt marshes of North America. A fibre has been obtained from the leaves.

Redwood Tree (*Sequoia sempervirens,* Coniferæ).—The wood of this tree is known as Californian Redwood. The bast tissue is used for making pulp for brown paper. It is also made into a kind of paper felt for non-conducting purposes. It has been used for the manufacture of

Fig. 93.—Poker plant.

vases, hats, and railway waggon wheels. Many of the wooden models required for class-teaching in elementary day and evening schools are made of Redwood.

Reed, Common (*Arundo Phragmites* or *Phragmites communis,* Gramineæ).—The culms or stems of this plant have been used for thatching purposes, and in France and Italy they have been utilised as brooms for dusting. The down has been recommended for paper-making.

In the North of England the plant is plentiful on the banks of rivers and meres.

The name of Ostrich Feather grass has been given to the plant as a local name. In September it is gathered for its white, flossy tufts, and is used for decorative purposes in place of the Pampas grass, on account of its cheapness.

Roussa Grass (*Andropogon Martini*, Gramineæ).—This is one of a number of Indian grasses belonging to this genus, the fibres of which have been used for paper-making.

Neamur grass oil is also extracted from this species.

Tussock Grass or **Mat Grass** (*Xerotes longifolia*, Juncaceæ).—This plant is a native of Australia, and belongs to the Rush family. The name *Xerotes* has been given to it on account of the aridity of the situation in which the plant grows, viz., a dry, open, and sandy country.

The leaves are considered a good substitute for Esparto grass. They are linear in form and of a leathery texture, but toothed at the apex and margins. The shoot or culm of this plant has been used for making baskets by the Yarra tribe, South Eastern Australia. Specimens are shown in No. 2 Museum of the Royal Gardens, Kew.

Wood Pulp.—This is rather confused and mixed up with paper-making. Wood pulp is prepared from Spruce Fir and Pine trees growing in Norway, Sweden, and America. The trees are cut down and deprived of their bark as much as possible, the ultimate cleanness of the pulp depending on the completeness with which this is carried out. They are next cut up into logs of a suitable size and the knots taken out, after which they are immersed in a liming solution.

There are two methods of manufacturing wood pulp; the one mechanical, applied to spruce (*Abies*) and pine (*Pinus*); the other chemical, in which all kinds of wood are used.

The mechanical process of wood-pulp manufacture consists in grinding the wood under water into pulp by edge runners, followed by treatment in a beating engine, the water abstracting most of the soluble impurities of the woody fibre, such as its gummy and gelatinous parts. Then the pulp is put through a kind of paper-making machine, and after undergoing a process of bleaching, is made into sheets.

The chemical process used in preparing wood pulp consists in boiling the wood, previously broken up into small pieces, with soda, sodium sulphite or sodium sulphate, whereby the impurities in the wood are more completely eliminated and a finer kind of pulp obtained. Chemical wood pulp is known in the trade as soda pulp or sulphite pulp or sulphate pulp.

The first is generally of a brownish colour, and is used for making brown papers. The sulphite pulp is of a good white colour, and is considered the best of the wood pulps. Sulphate pulp is rather darker in colour than sulphite pulp; it is only made in small quantities. After boiling with chemicals, the wood is made into a pulp by treatment in a grinding mill and beater, and then it is made into thin sheets in an ordinary paper-making machine.

In making paper from wood pulp it is frequently, although not always, ground up with some water into a damp paste. Then this is thrown into a beating engine, in which it is further ground with water into a pulp. While in this engine it is treated with bleaching powder, if necessary, to bleach it, thus imparting to it a good white colour. It is afterwards mixed with China clay and resinous sizes, to give it the qualities of a good paper, and in this condition it is sent to the paper-making machine. Wood pulp is used chiefly for making paper for newspapers.

Writing papers and book papers are still made from rags, although in the preparation of some cheap kinds a little wood pulp may be mixed with them.

Wood-pulp paper deteriorates with age and wear; it breaks up into small particles or dust. Its spontaneous combustion is very doubtful.

Formerly it took sixteen hours to make a ton of rags into paper, but at the present time one ton of pulp can be made into paper in an hour and a half. This is mainly due to improvements that have taken place in the processes employed in the manufacture. The bales of wood pulp weigh about 400 lbs.

Most paper machines have ordinarily from seven to fourteen cylinders. A machine at a paper mill at Barrow-in-Furness is said to have fifty-two cylinders. On the other hand, in America it is sometimes customary to work a machine with only one cylinder.

Wood pulp, whether mechanical or chemical, is sold in two forms, viz., moist and dry. The moist pulp contains 55 per cent. of water, while the dry pulp contains 10 per cent. of water, and they are bought and sold as containing those quantities of water or moisture respectively. Wood pulp naturally contains from 8 to 10 per cent. of water, and this is known in the trade as atmospheric moisture. In buying and selling moist pulp, allowance is made to the extent of 10 per cent. for such moisture. Moist pulp is therefore considered to contain 50 per cent. of air-dried pulp, made up of 45 per cent. of pulp and 5 per cent. of atmospheric moisture.

Parcels of wood pulp often contain more water than the quantities named above, and then they have to be sampled and tested. To carry this out, 2 per cent. of the number of bales are taken and weighed, and from these weights the total weight of the parcel is calculated. Samples are then cut from sheets taken from the top, centre, and bottom of each bale, and in these the percentage of water is ascertained by drying in a hot oven at 212° F. From the results any allowances for excess water in the pulp are calculated.

BRUSH AND MAT MATERIALS.

THESE are chiefly obtained from the vegetable kingdom, but a fair variety have an animal origin.

"Arenga" is the generic name of a palm found growing in India. It was introduced into England in 1830. The leaves are lance-shaped, with the margins entire or notched. The bases of the leaves are white, and silvery beneath. The spadix of the flowers is branched and contains numerous fibro-vascular bundles. The leaves are first washed, then soaked in an alkaline solution, and the fibres obtained used for brush-making.

Comparatively few plants have as yet afforded material suitable for making brushes, but the number might be considerably increased if special search were made.

Brushes of vegetable construction have been used from a very early period. It is stated that in Roman times the best brooms were made of palms. The Butcher's broom, *Ruscus aculeatus*, has derived its English name from the fact that butchers used to sweep their blocks with the branches of this curious plant, bearing their flattened, leaf-like branches or phylloclades.

One writer says: "In the way of history, not much is to be gathered about our subject. That brooms for cleaning and sweeping purposes have been known since the very earliest periods and the rudest and most uncivilised people, is certain enough. Amongst the relics belonging to the iron age disentombed from the peat mosses of Sleswick, were found two birch brooms,[1] curious manifestations of ancient tidiness. The remains, amongst which these brooms were found, probably belong to the second or third century, as is evidenced by Roman coins mixed with them. In classical writers from Homer downwards, we find, as might be expected, casual references to these domestic implements. In the animal kingdom the bristles and hair of the goat, squirrel, sable, marten, badger, and hog are utilised, some for the finer kinds, and others for the coarser kinds of brushes."

In the manufacturing industries brush fibres are largely used. The banister or handle-brush is used in spinning and weaving mills for cleaning the intricate trains of wheels in the self-acting mule headstocks and other working parts of machinery. In the manufacturing department it is found quite as useful for loom cleaning. Another well-known brush, commonly termed the "Busby," is a circular or conical hand-brush, made by Messrs Shaw according to the Equitable Fire Insurance Company's

[1] Lubbock's *Prehistoric Times*, p. 9, ed. 1872.

instructions as a special appliance for fire-extinguishing purposes. It is used by dipping the brushes into buckets of water and then applying them to such portions of machinery as may have caught fire. It has been found very effective in extinguishing fires in their early stages in cotton mills, particularly in the wooden parts of "self-acting mule" carriages, which are saturated with oil, and are liable to fire from friction of the tin roller studs and bearings. The use of vegetable bass and bundle fibres has increased of late years.

The picking of succulent pendulous fruit, such as red and black currants and gooseberries, is now done to a great extent by brush machinery in the largest jam works. The apparatus consists of revolving brushes attached to shafting. The fibres of the brushes are just sufficiently pliable as not to damage the fruit, and yet are capable of detaching the pendulous branching stalks.

A stiff kind of bristle-like fibre is used as a burnishing brush by calico printers, for clearing out the colour dirt of copper rollers.

A stripping brush is used for cleaning the main cylinders and doffers of carding engines, and another for brushing out impurities from revolving flats. These are sometimes made in a spiral form. Copper-roller brushes and iron-roller brushes are generally made of short, stiff fibres. In fine spun yarns of the Bolton district of Lancashire, it is customary to comb out the short fibres, and a comber-brush is used to clean out the waste fibres. A mill broom, with fibres of a similar texture to the banister brush, is used in spinning-rooms and weaving-sheds from hogs' bristles.

A cog-wheel grease brush is made flat with a long handle, so that grease may be placed on cog-wheels while they are in motion. For lime washing, bristle fibre brushes are in constant demand, as also for cleaning the twist yarn in the winding frames. Hair brushing is done by hand and machinery; also chimney cleaning or sweeping on a large scale, and bottle cleaning by mineral water manufacturers.

Circular revolving brushes are made with whisk fibres, which are very stiff. They assist in raising and cleaning the nap in "Moser" raising machines in woollen manufacture.

A few of the names given to brushes that are in constant demand include The Hair Stair Carpet, Hair Double Banister, Long Whisk Banister, Short Cut Whisk Carpet Broom, Victoria Whisk Carpet Broom, The Set Chamber Whisk Carpet Broom, Weed Broom, Black Lead, Scrubbing and Laundry Brushes, Cocoa-nut and Hair Banister Brushes, Bottle Brushes and those used for Electric Dynamo Installations, also the Ewbank Carpet Sweeper and Copbottom Paste Brushes.

Coarse interlaced plaitings of cane are used as carpet beaters, and enamelled thin pleats of cane are intersected so as to imitate the structure of plain cloth. These are used with a coating or pad of horse-hair, or an imitation horse-hair yarn with the top surface of wool. These fabrics have come into use as cane enamelled socks for the prevention of rheumatism, and for comfortable and hygienic wear.

Bahia Piassava (*Attalea funifera*, Palmaceæ).—This palm tree grows to a height of 30 to 40 feet in the forests of Brazil. The bases of the young leaves are encircled by a fimbriate arrangement of chocolate-coloured appendages during vernation. These structures are the bristle-like fibres of commerce. They are removed by the natives, who use a small axe for the purpose.

The fibres undergo a rough process of heckling, straightening, and cleaning, and are made into bundles weighing 80 to 100 lbs. They are then ready for the market. The fibres are much in demand for brush-making. A good export trade is done in them. They are very much used in the large, revolving street brooms that are now employed so commonly by the sanitary departments of Corporations in the large cities and towns, and by Urban District and County Councils. The setose fibres, being of a stiff nature, are well adapted for getting the sludge and dirt off the roadways, pavements, and channels in public thoroughfares.

Fig. 94 shows the bristle fibres of *Attalea funifera* when adapted for roadway brush purposes.

The rigidity of the bristles, the uniformity of the individual fibres, and the peculiar dark brown colour are remarkable features of these bristle fibres.

The discovery of the Bahia bristle fibres was due to a very singular circumstance, which is related by Dr. Yeats in his *Natural History of Commerce* as follows:—"To protect the hull of his vessel from the rough walls of a quay in a Brazilian port, the captain had caused a sort of round fender to be made of weeds that grew on the river banks. The same fender was used for a similar purpose on his arrival in the docks of the Mersey, and at length left on the shore. A brushmaker looked at it, and begged it, worked it up, and soon wanted more of it; it was the Piassava now used for coarse stable brushes and street-sweeping brooms."

The staples or qualities of Bahia piassava are classed under several marketable headings, and were quoted by Messrs. Ide & Christie on 19th April 1899 as follows:—

Good to prime, 37s. to 39s. Medium, 30s. to 34s. Common, 25s. to 28s. Other remarks: "Bahia continues quiet. Fair demand for the better qualities."

The elasticity of Bahia fibres is well marked, and a test made of the pulling strains gave the following results in pounds: 17, 15, 7 in one test; and in a second test, 19·5, 5, 3 lbs.

Bamboo (*Bambusa*, Gramineæ).—The stems of Bamboo, after being cut down in the green state, are split up and made of the required length, being then mixed with other fibres or bristles for coarse brooms and for scavenging implements. Paper has been made from the cane-like stems, which are first bruised, then steeped in water, and formed into a paste. The stems have been used for a variety of purposes, such as bridges, masts, boxes, mats, and drawing-room ornaments. India is the home of these plants. Sir J. D. Hooker, in his *Himalayan Journals*,

Fig. 94.—Bristle fibres of *Attalea funifera*.

mentions an interesting circumstance as follows:—"At about 2000 feet, and 10 miles distant from Darjeeling, we arrived at a low, long spur, dipping down to the bed of the Rungeet at its junction with the Rungms. This is close to the boundary of the British ground, and there is a guard-house and a sepoy or two at it. Here we halted. It took the Lepchas about twenty minutes to construct a table and two bedsteads within our tent; each was made of four forked sticks stuck in the ground, supporting as many side-pieces, across which were laid flat pieces of bamboo, bound tightly together by strips of Rattan Palm stem. The beds were afterwards softened by many layers of Bamboo leaf, and if not very downy, they were dry and as firm as if put together with screws and joints."

The stems of Bamboo, when spliced, are known in the brush trade as the Bamboo fibre. The fibres used are about $\frac{1}{8}$ of an inch in width and 6 or 7 inches in length. They have a good elastic bending property, and are of a straw colour. The lengths are varied to suit the requirements of the trade. This material is also known to the trade as "Patent Bass." These fibres will take a good dye with little or no damage to the fibre itself. They are very strong, four tests giving the following results, viz., 25, 45, 35, 20 lbs.

Bass, Monkey, or **Grass, Leopoldinia Piassava** or **Para Piassava** (*Attalea piassifera*, Palmaceæ). — This useful palm grows in the Brazils. It is remarkable for its persistent petiole bases, which often terminate in long and pendulous appendages of bristle-like fibres.

Fig. 95 is a young plant of *Leopoldinia*, probably the piassava of commerce. The bristle-like fibres are combed out and then cut off from the young plants. The fibres are used as a substitute for bristles by brushmakers, and are made up into stout brooms and cylinder sweeping brushes. The plant grows from 20 to 30 feet high, in dense tropical forests.

Fig. 96 is an illustration of Monkey Bass fibres, just as they are received at the brush factory. These fibres are of a faint russet-brown colour and remarkably flaccid. They vary from 2 to 5 feet in length; in form they are rather angular, longitudinally striated, and tapering to a thin point, from a pretty broad base. The tapering is considerable, as the illustration shows. The fruit of this plant is the Coquilla nuts of commerce, while the pericarps have been used for making umbrella handles.

The values of Monkey Bass or Para Piassava was quoted by Messrs. Ide & Christie on 19th April 1899 as follows:—"Para—only a small business passing—values fairly steady. Medium, 30s. to 32s. Damp ordinary, 32s. to 34s. Fair to good, 35s. to 38s."

Good fibres of Para have a strong and wiry feel, are fuscous in colour, and according to tests made by Mr. G. H. Hurst, F.C.S., of Manchester, the breaking strain varies from 2 to 25 lbs.

Bass, Madagascar, or **Vonitra** (*Dictyosperma fibrosum*, Palmaceæ).— The fibres obtained from *Dictyosperma* are round, tapering, thread-like in appearance and of a deep brown colour. They are moderately strong, and when stretched to an undue extent break with a fair amount of elasticity. The fibres vary in length from 1 to 2, 3, or 4 feet, some even reaching a length of six. They gradually taper to a fine, but rather obtuse, point.

The basal portions of the fibres are flattened, but gradually become cylindrical; they are of great flexibility. They are sometimes imported in large bundles under the name of Vonitra. Some fibre bundles of Madagascar reach over 6 feet in length.

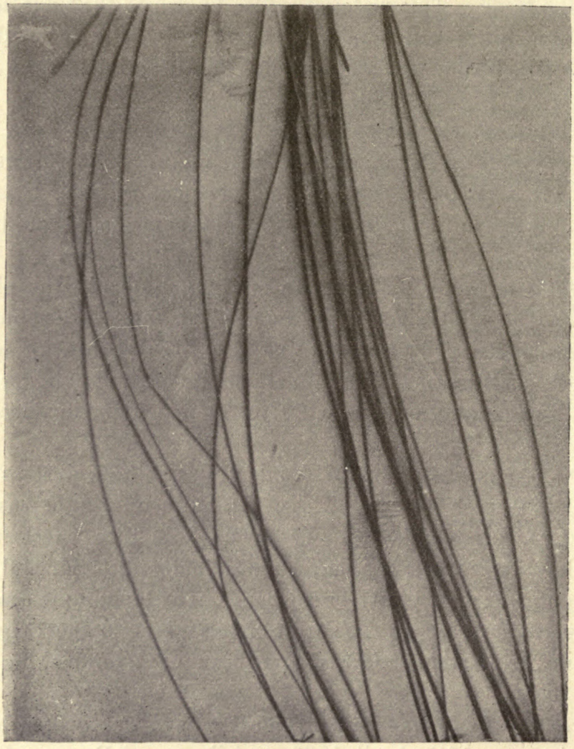

Fig. 95.—Bass, or Piassava Grass.

Of this plant Dr. Morris says: "For many years a long, fine fibre, of a rich brown colour, has been obtained from Madagascar, closely resembling 'Para piassava.' The name of the plant was recently determined when it was described in the *Kew Bulletin*, 1894, p. 358. It is *Dictyosperma fibrosum*, known locally as Vonitra. The fibre is finer and more flexible than Brazilian piassava. The quantity received has always been limited, and lately it has almost disappeared in the market.

"The high quality may be gathered from the fact that the last prices paid were £46, 6s. per ton with Good to Prime, etc. When well cleaned Madagascar took rank as a first class-fibre.

"Since the above date Madagascar fibres have come down in price, even so low as 15s. to 38s., and little business is being done at these prices. It has also become scarce. It is possible that inflated prices were reached at its introduction into commerce, but these have gradually

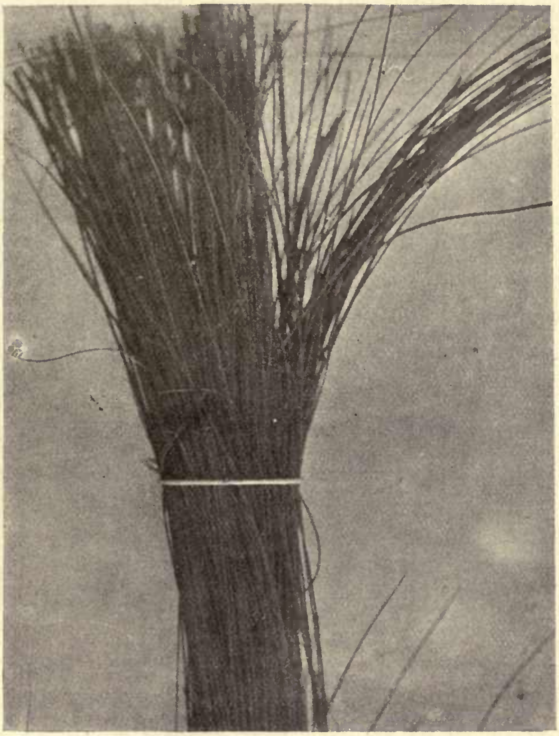

Fig. 96.—Monkey Bass fibres.

worked down. "Some good specimens of brushes made from this fibre are to be seen in the Economic Museum of the Royal Gardens, Kew." Quite recently, however, it has come in large quantities, and has been sold at from £50 to £60 per ton.

The breaking strain of the fibres of Madagascar piassava in pounds weight were as follows: 5, ·5, ·5.

Bass, West African (*Raphia vinifera* or *Mauritia vinifera*, Palmaceæ).—The plant producing the West African Bass is also known as the Wine palm; hence its name of *vinifera.* It grows extensively in West Africa and in Lagos. It is said to cover 5000 square miles.

The fibres are long, their length varying from 3 to 4 feet. They are obtained from the leaf-stalks; their bristle-like character renders them suitable for stiff brooms.

These fibres are commercially of recent origin and have been used by the natives for fishing-lines. The prices obtained for this kind of fibre is generally below that of the Monkey and Bahia kinds. A few years ago the price was £12 to £16, now it is £20 to £30 per ton.

Fig. 97 shows a bundle of specimens of the bristle-like fibres of the

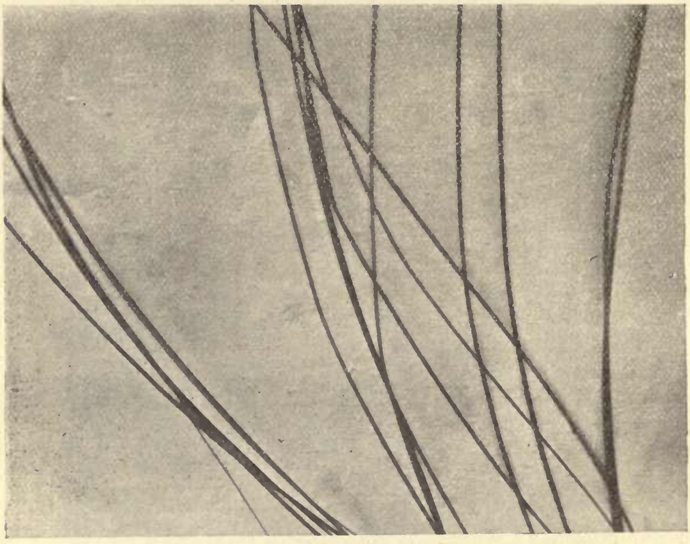

Fig. 97.—West African Bass fibres.

West African or Cape Bass, natural size. They vary considerably in thickness, as shown in fig. 96; their surfaces are rough and of an irregular russet-brown colour. They are strong and wiry in texture. After the fibres have undergone a cleaning, they are more rotund and uniform in thickness, and possess a considerable amount of pliability. They are utilised with Monkey Bass for the purpose of making the cheaper kinds of brooms.

Sir Anthony Moloney published an account in the *Kew Bulletin* of 1891, p. 4, as follows:—"When the leaves are cut away from the lower part of the palms, portions of the leaf-stalk are left adhering to it. These leaf-stalks encase the trunk, and project upwards and outwards, forming *Chevaux de frise* all round it. From the fibre in these stumps native fishing-lines are made. It is extracted by simply soaking in water and scraping. The process is very simple, and fully understood by the natives. It is the stronger portions of this fibre which are exported as 'West African Bass.' There is no reason why, with a population in the habit of preparing it and a source of supply which may be regarded as practically unlimited, we should not be able to compete on even terms with the sources of supply which at present monopolise the market.

"Since 1890 West African Bass has become a regular article of commerce. The prices are usually below Para and Bahia fibres. At the beginning of 1895 the arrivals were heavy; prices, £12 to £60 per ton."

The Cape or African Piassava fibres are taking the place of Bahia fibres. In some cases certain selections are made of African to mix with Bahia. So recently as April 1899 West African Bass could be bought for £14 per ton, and on the same date Bahia was selling at £28 per ton.

The fibres are very strong, and the breaking strain of four fibres were as follows in pounds weight, viz., 20, 21, 33, 32.

Bassine or Palmyra Fibre (*Borassus flabellifer*, Palmaceæ).—This palm tree is a native of the East Indies, and grows to a height of 30 feet. It was introduced into England in the year 1771. The leaves are about two feet long, and are divided into fan-like segments. A fine specimen of this palm may be seen growing in the Victoria Regia House at Kew.

The fibres of Palmyra or Bassine are imported in bundles. The individual fibres are flat, but become roundish near the apex. They have a dull russet or straw colour. The leaves have been used for umbrellas and hats. The fibres in texture are stiff, thin, wiry, and make a grating sound when pressed together. They are slightly flexuose, strong, and elastic. The hollow trunk of this palm has been made into musical drums in some parts of India. One of these is exhibited in the cases at the Economic Museum of the Royal Gardens, Kew.

The fibres produced from the Palmyra palm are keenly competitive with those of "West African Bass." Messrs. Ide & Christie, on 15th April 1899, reported on Palmyra as follows:—"No change to record. Business passing is quite of a retail character; dealers only prepared to operate when they have orders in hand from their manufacturing friends. Only a fair monthly delivery. Imports continue plentiful and stock increasing." Quotations—Good, £26 to £29. Medium, £20 to £24. Common, £16 to £19.

Palmyra fibre was introduced into notice in the eighties. It was at first little thought of, but latterly it has come into demand.

Besom Stuff or **Ling** (*Calluna vulgaris*, Ericaceæ).—This plant, known as Heath, Ling, or Yearth, grows plentifully in the moorland districts of the North of England, serving as a protection to the grouse in the moorlands, and in the Highlands of Scotland. The rigid woody stems and branches of the plant are cut in the summer and made into

A B C

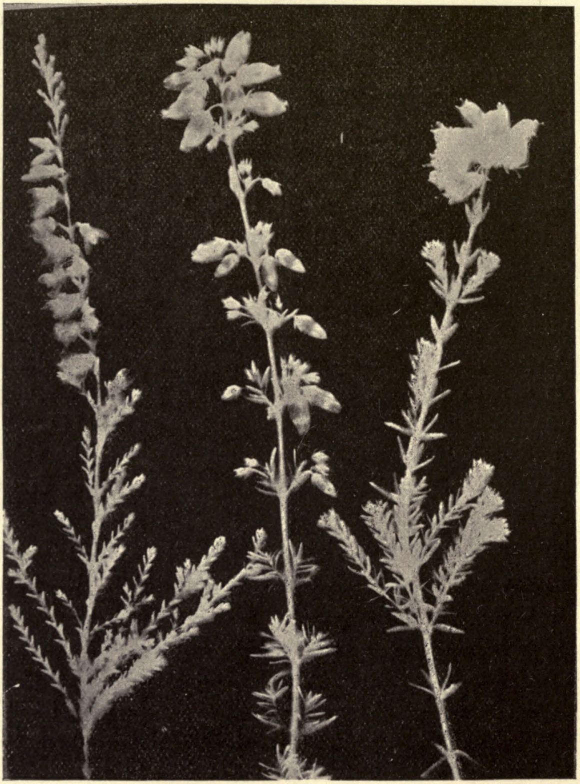

Fig. 98.—Heaths.

stable and yard brooms, for which they are very suitable. Formerly a very important trade was done by poor people living in the outskirts of towns, who gathered the cut twigs of the ling, and made them into brooms in order to sell them in the towns as besoms. In the sixties and seventies besom-making was in a flourishing state. Up to this time the art of brush-making had not made much headway as far as the coarser brooms were concerned, and many of the foreign fibrous plants that have now come into repute were not then known in what may now be called the "Bristle World." The chief sale for the besoms was in the Lancashire towns of Oldham, Rochdale, and Ashton-under-Lyne, Staleybridge in Cheshire, and Glossop in North Derbyshire.

In the hamlets outside these towns one meets with such names as Besom Hill and Besom Row. The late Mr. Ben Brierly, a famous writer in the Lancashire dialect, wrote an interesting story under the title of "Besom Ben." The principal character in the story was a famous vendor of the besoms, who went about hawking them strung on the saddle of his donkey. The prices paid for besoms varied from 3d. to 6d., depending upon their size and make up and the general demand for them. The young shoots of the ling are slender and fir-like. They bear numerous axillary pale peach or pink-coloured flowers. The plant belongs to the Ericaceæ or Heath family.

The letter A, fig. 98, shows an example of the arrangement of flowers, and the peculiar Gothic structure of the young branches, showing an architecture that has been pointed out by Ruskin in his work termed *Proserpina.*

B shows a flowering twig of the fine-leaved Heath, *Erica cinerea.* The urn-shaped flowers of this plant are of a dark peach colour, and are grouped together in numerous rosettes.

C is an example of the cross-leaved Heath, *Erica tetralix.* The flowers of this plant are shortly urceolate, of a pale pink colour, and often appear in a crowded rosette at the terminal part of the twiggy shoots.

The general arrangement of the leaves shows a decussation or crossing at right angles, hence the name of "Crossed-Leaved Heath." It is very probable that the flowers of this plant are the "Heather Bells" of most poetical and literary writers.

Latterly the twiggy portions or branches of ling and heather have been used for the making of brushes and brooms, in combination with the pine and graceful twigs of the birch tree.

Broom Root (*Chrysopogon gryllus,* Gramineæ).—The roots of this plant have been introduced as a cheap substitute for the French Whisk or "Chiendent." The fibres of Broom Root are less strong and finer than those of the Mexican Whisk, and of a rather darker yellowish colour. When dressed, they are more than a foot in length.

French Whisk.—There is a fair demand for it in the brush-making industry. They are imported in bales of 100 cwts., etc.

Coir Fibre (*Cocos nucifera,* Palmaceæ).—The plant producing the coir fibre is the Cocoa-nut palm. It is a native of the tropics, where it grows in immense groves. It was introduced into this country in 1690, and is certainly one of the most extensively useful palms we know. Loudon says: "The leaf, when reduced to fine fibres, is the material of which a beautiful and costly carpeting is fabricated for those in the higher ranks. The coarse fibres are made into brooms. After these useful materials are taken from the leaf, the stem still remains about the thickness of the ankle, and furnishes firewood."

Fig. 99.—Brown Coir fibres.

The fruit of the plant is about the size of a man's head.

The outer covering is the husky pericarp or fibrous portion. It is often broken open longitudinally by a small hatchet, which is held in the right hand while the pericarp which receives the blows is in the left hand. It is generally broken into two parts, which are sometimes sold as scrubbers, without any further preparation, to the housewives of operatives in the North of England, at the rate of seven for sixpence.

The thick pericarp forms the coir of commerce, the fibres of which have long been used in India for cordage.

The cocoa-nut fibre is made into ropes, brushes, brooms, matting, nose-bags, and cables.

The longest fibres are used for spinning purposes, and the shorter ones for stuffing material. When dyed, they form a substitute for horse-hair.

In order to detach the fibres from the pericarp freely, a steaming process is resorted to, which has the effect of softening the husk and the fibres composing it. The fibres are at first willowed to remove the adhering particles or impurities.

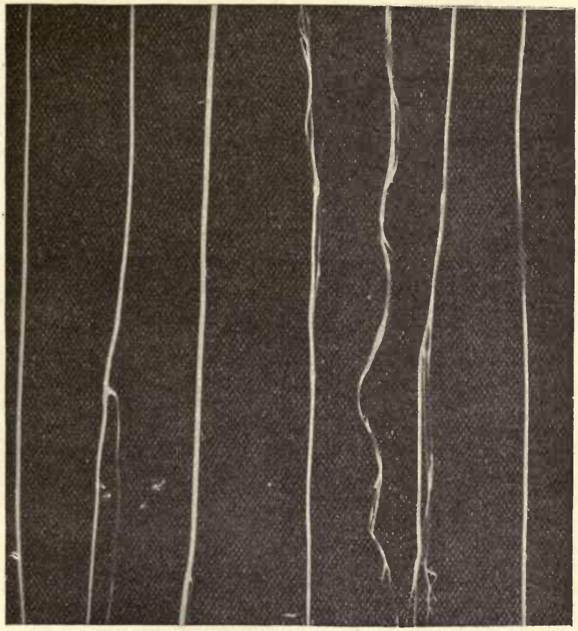

Fig. 100.—Coir fibres.

Fig. 99 shows the brown tufty fibres taken from the exterior shell of the cocoa-nut. After having undergone some operation of dressing, they are ready for the brush-maker.

In some countries where the Cocoa palm grows near the sea, the nuts are buried in holes, so that the sea-water may cover them. This has the effect of macerating the fibres, and readily differentiates those which are best adapted for weaving into mats and other purposes.

Fig. 100 shows a number of coir fibres used for sweeping brushes. Some of them are distinct enough, but others split up into thinner flexuose portions. This fusing of the fibres with the lateral divisions has a good effect on the crossing of the large tufts of fibres when made into brushes used for staircases, lobbies, and similar places.

Fig. 101 shows a bundle of dressed fibres of Gaboon. These are used for very rough brushes where a stiffness is required in the bristle. When these have been drawn the thinnest are suitable for mixing with

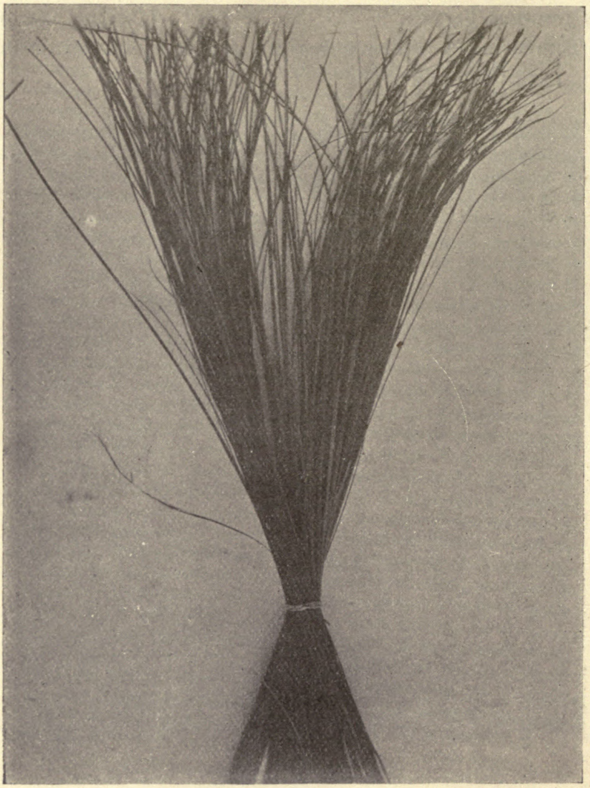

Fig. 101.—Gaboon Piassava.

other brush fibres. Gaboon fibres are regarded in the trade as a stiff variety of the African Bass or "Piassava."

The fibres are flattened at the base, but in the body part become rounded, with a flattening at the apex. The basal portion has a whale-bone-like appearance, but is straw coloured at the apex. The fibres are very strong, their breaking strain in pounds being as follows:—27, 30, 43, 30, 35.

Kitool Fibre (*Caryota urens*, Palmaceæ).—Kitool is a Palm tree found growing in the East Indies to a height of 40 feet. The broad-leaved fronds are bipinnate, the leaflets wedge-shaped, and the stem is ringed or annulated. This plant was introduced into the palm houses of Great Britain in 1788.

From the sheathing appendages of the leaves of this palm tree, certain fibres are obtained that serve almost as bristles. In a natural state the fibres of Kitool are strong, flaccid, and wiry, round or flat, with tapering, obtuse ends of a dull black or slate colour.

From these fibres a rope of great strength has been made. The wiry nature of the fibres obtained from the leaves has been utilised in making ropes with which to tie up wild elephants.

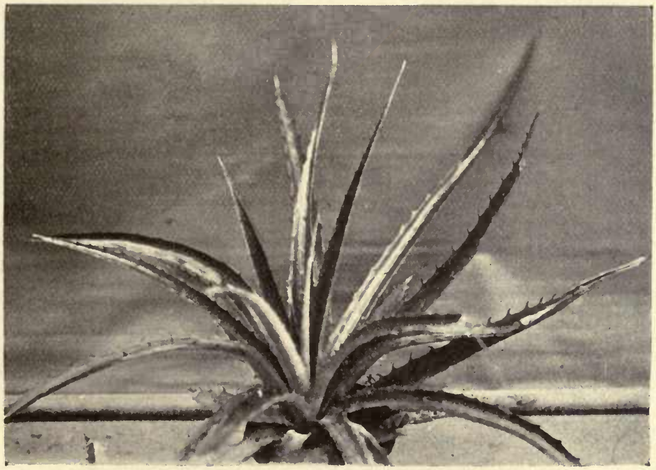

Fig. 102.—Istle fibre plant.

The fibres are much in request for brush-making, and some of the finest have been used as a substitute for bristles.

Kitool bristle fibres are imported under three principal qualities, known respectively as Nos. 0, 1, 2, and 3. The value of these kinds were quoted by Messrs. Ide & Christie, on 20th April 1901, as: "Values—Long, 8½d. to 9d.; No. 1, 6½d. to 7d.; No. 2, 2¾d. to 3¼d.; and No. 3 at 1d. per lb."

Tests made of the pulling strain of Kitool fibres gave the following results:—4, 3, 5, 5, 4 lbs.

Mexican Fibre or **Istle** (*Agave heteracantha*, Amaryllidaceæ).—This is an Aloe that grows in the mountainous districts of Mexico. The basal leaves of the plant are numerous, broad at base, channelled, serrate with horny spines in the margins, and taper to an acuminate horny point.

Fig. 102 is a photograph of an Istle fibre plant. The fibres are known as Mexican, and are leaf-structures running parallel in the leaf-tissues.

There are several varieties of Mexican fibre, the names for which are mostly commemorative of the districts where the plants have been grown, such as Jaumane, Tula, and Matamoras. The Mexican fibre industry is mainly carried on at San Luis Potosi.

Fig. 103 is a group of fibres (natural size) from the Istle plant. Their length varies from 12 to 30 inches. In form they are angular or round, somewhat resembling Sisal hemp fibres, but differing in the colour,

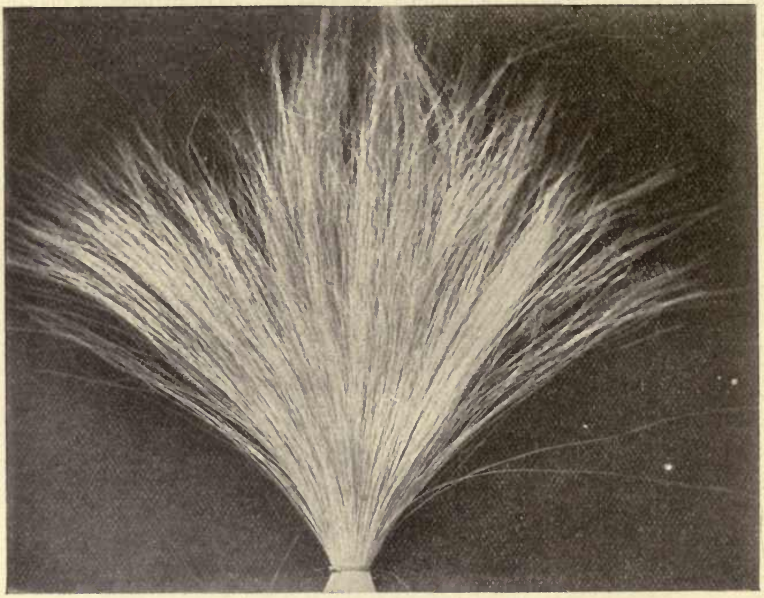

Fig. 103.—Istle fibres.

which is of a light canary yellow. Their bases are thickened, and in texture they are more wiry. The fibre is in good demand, and is much used in the making of cheap nail-brushes. It is also employed, mixed with hogs' bristles, in the manufacture of some of the cheaper kinds of brushes. On 15th April 1899, Messrs. Ide & Christie reported as follows:—Firm. Extra long, 26s. Fair, 22s. Common, 20s. Similar prices ruled in December 1901.

In making some fancy brushes, where strength in the fibres is not an important factor, the fibres of Istle are very serviceable.

The flexibility, glossiness, and fineness are characters that are of value in these fibres. A test made as to strength gave the following results, viz., ·5, ·4, ·5 lb. respectively.

Whisk, Mexican (*Epicampes macroura*, Gramineæ).—The roots of this plant are exported under the name of "Raiz de Zacaton." It has been used in France and Germany in the manufacture of velvet and clothes-brushes, and for horse-hair bristles. The fibres soon become brittle, even with only slight usage. Hair-brushes and combs have been made from the roots of this species.

The coarse and tufty roots are collected by hand.

Very little treatment is necessary to prepare the fibres, beyond immersing the roots in water and drying them in the sun.

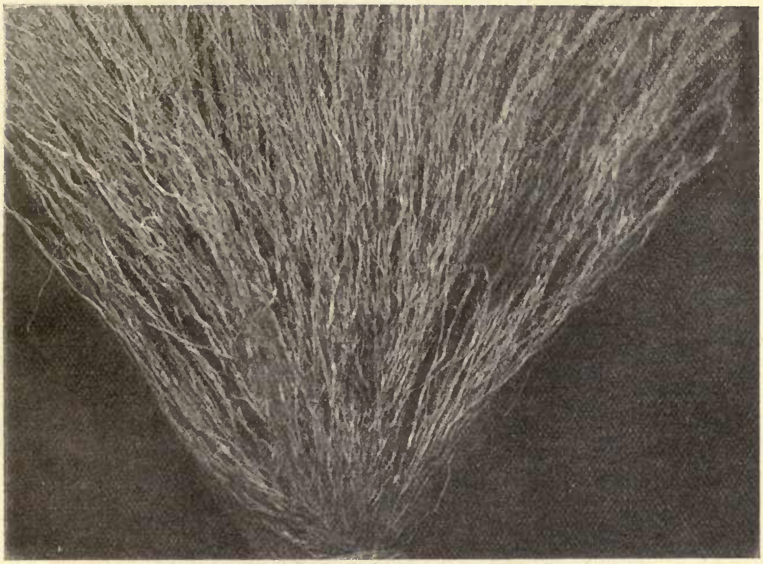

Fig. 104.—Mexican Whisk.

Mexican Whisk fibres have a yellowish white appearance; they are remarkably flexuose, strong in texture, and will bear a fair amount of strain.

Hamburg is the great market for this fibre; also the United States and France; but in England it has not taken hold to any great extent. The price varies from 5d. to 10d. per lb., according to the quality of the material. The amount imported shows a considerable increase in late years as compared with former years.

Fig. 104 shows a prepared bundle of the "Mexican Whisk" when ready for the use of the brushmaker. The fibres of Mexican Whisk, when made into brushes, have a good rough-and-ready cleaning action. They are more stiff than lively. The breaking strain in pounds from a test gave ·25, ·25.

Millet, Indian (*Sorghum*, sp., Gramineæ).—Fig. 105 shows a contracted arrangement of panicles of the Indian Millet in fruit. The fruits are much in demand as food for cage-birds. When they have been removed, the panicled portion of the stem, known to botanists as the inflorescence, is suitable for whisk purposes. The stem is stout and rigid, and gives the fruit of millet a conspicuous appearance when mature. The panicle has a more spreading habit than that of the Italian whisk (*Sorghum*).

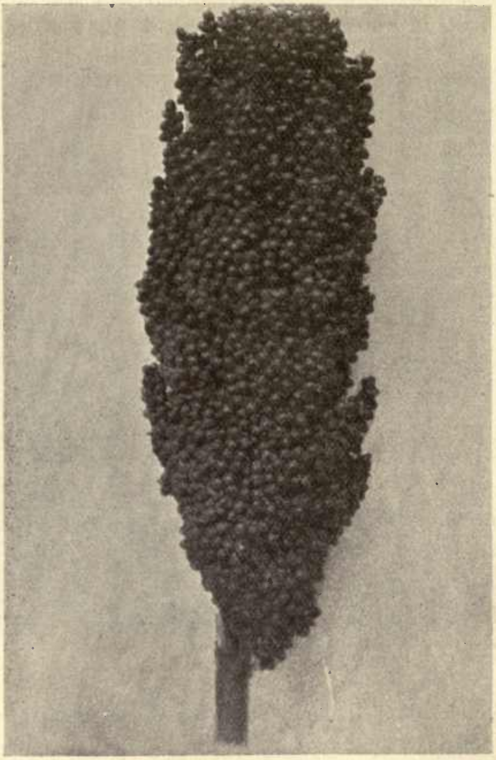

Fig. 105.—Indian Millet.

Palma Fibre or Jute.—These fibres are about one to two feet in length, but fine, solid, and thread-like, slightly flattened, and of a dull yellow or white colour.

Fig. 106 is an example of Palma fibres. They bear some resemblance to Istle fibres, but tend to cohere more closely together. They are wanting in the elasticity and liveliness which are generally the characteristic features of Istle. They have been used as substitutes for certain brush fibres. They are exported from Mexico, and from their general structure, fineness, and needle-pointed ends they are evidently prepared from some plant allied to the genus Corchorus (*Tiliaceæ*). The pulling or physical strain of three of these fibres varied as follows in pounds:—·125, ·3, ·15.

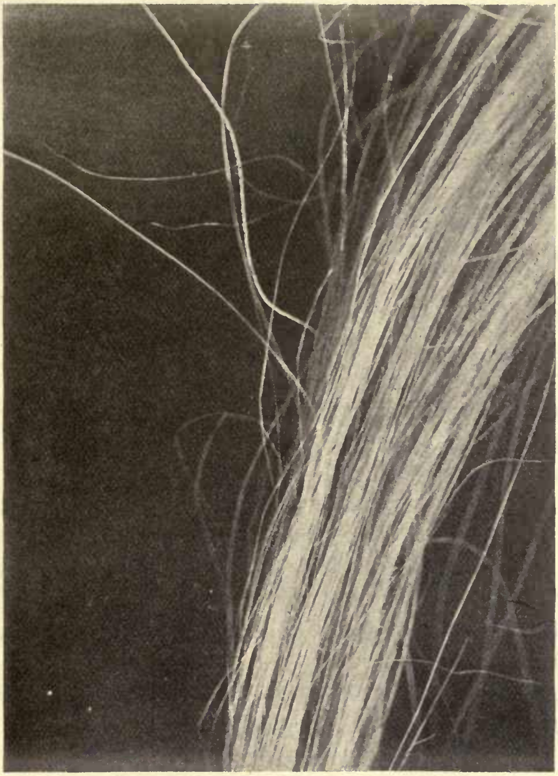

Fig. 106.—Palma fibres.

Straw (Hats) (*Triticum æstivum*, Gramineæ).—The straw of wheat stems is used for the purpose of plaiting into hats. The principal species from which the straw is obtained is *Triticum turgidum*, a native of Egypt. It is mainly used by the Italian plaiters in the districts of Florence, Pisa, and Tuscany.

In England the principal seats of this industry are Luton, Dunstable, and Bedford. The straw of wheat grown on dry, chalky lands is manufactured into hats. The principal part used is the middle internode, above the last joint. This is cut into lengths of 8 or 10 inches, and split to form the plait. The latter is often bleached and dyed of a red, purple, bronze, or yellow colour before plaiting.

Uva Grass (*Gynerium Saccharoides*, Gramineæ).—A native of the Brazils, known commercially as Uva grass. The leaves of the plant have been used for straw hat-making purposes.

Vegetal (Crin) (*Chamærops humilis*, Palmaceæ).—These fibres are also known as "Vegetable Hair." They are obtained from the plant known as the Dwarf Fan Palm. This species is well known as a handsome one for decorative purposes. It is a native of Southern Europe. The fibres are obtained from the leaves, and have been used extensively as a substitute for horse-hair. In this state it can be twisted and curled, owing to its flexibility. It also takes a good dye.

It is imported into this country in bales of over 200 cwts. each.

On 17th April 1899 Messrs. Ide & Christie reported: "Black Curled, steady, 10s.; Green, 6s.," etc.

Whisk, Italian (*Sorghum*, sp., Gramineæ).—Fig. 107 shows specimens of a species of Millet. This kind is imported as Italian Whisk.

The stems are round and cane-like, with a smooth surface; they grow to a height of from 4 to 6 feet. The branches or panicles upon which the millet fruit is borne are zigzagged, round, wiry, and somewhat ascending or erecto-patent, which renders them handy for the making of the whisk brushes used by hairdressers, tailors, drapers, etc. The French name for this whisk is "Paille de Sorgho." The seeds are yellow, and are protected by the close-set panicles of wiry bristle awns.

For specimens of almost all the bristle fibres used in brush-making, and for permission to photograph them, I am deeply indebted to the firm of Shaws, Limited, Hanover Street, Manchester, and Warre Street, Ashton-under-Lyne. Mr. George Shaw, of the same firm, has given me every facility for seeing the processes through which the fibres are put before being sent out for use in the trade, and to him I owe my thanks.

The following is a draft of the prices reached in the Bass group and year's fibre supply, as given by Messrs. Bastone & Firminger, of London, in *The Times* of 5th January 1900.

"Fibres.—Palmyra has been dull throughout the year, with very little change in values. Stock is now lower by about 400 tons, and stands at about 800 tons in London public warehouses. Recently, a rather better feeling has been manifested. Bristle Fibre.—During the year consumption has afforded relief to the congestion of stocks, and the market is now in a healthier condition than for several years past. Recent realisations have shown a moderate improvement, and this should continue in the New Year if supplies are not excessive. Kitool Fibre.—

Low as prices commenced, they have seen a further shrinkage, though not to any considerable extent. They now stand at, per lb., No. 0, 9d.; No. 1, 6d.; No. 2, $2\frac{3}{4}$d.; No. 3, $1\frac{1}{2}$d. Consumption has been decreased by reason of Palmyra fibre being to a certain extent used in the form of an adulterant or substitute for some purposes. Qualities have shown a marked falling off compared with a few years ago. Bahia Piassava has remained dull of sale. Compared with competing contemporary fibres

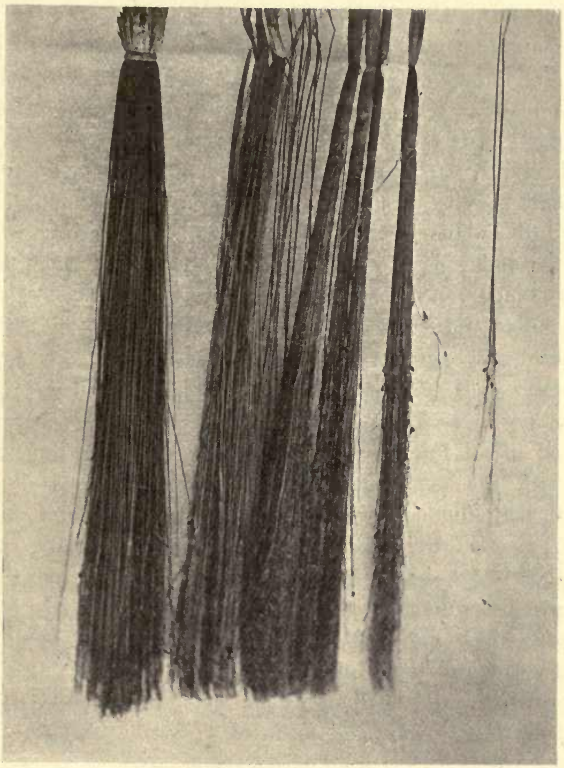

Fig. 107.—Italian whisk.

it is still out of price, and prospects are that it cannot resume anything approaching its former volume of trade and importance of position until cost recedes to something approaching old values, say, £10 per ton down from present range. African Piassava has been subject to considerable vicissitude of price, being determined entirely by imports, and these have been most irregular both in quantity and quality, and during the past few months have been excessively large, and values of the leading line, Grand Bassa, have been brought to from £11 to £19 per ton. Para Piassava continues of diminished importance. Prices run from £35 to £45 per ton, according to quality, but they are only retained to that level by the speculative position. Madagascar Piassava.—Trade is very small in consequence of absence of supplies, and the same cause has driven prices up inordinately. Current values, say, £30 to £45 per ton. Prospects good if supplies keep moderate. Raffia fibre has been a better market, with closing values at £40 to £42 per ton. Stocks are moderate and prospects fair. Coir Yarn.—The year opened, in face of the stocks and large consignments which had come forward, very dull and quiet, but gradually improved towards the spring, and on it becoming known that there had been a partial failure of the monsoon prices steadily stiffened for all descriptions and closed firm, showing a rise from January 1 of £1, 10s. to £2 per ton, and stocks being considerably depleted there is every prospect of these prices being maintained. Coir fibre was dull and neglected during the early part, consequent on large consignments and consumers being fairly filled, but, again, the partial failure of the monsoon has made fibre scarce, and the market closes with some demand at quite £2 to £3 per ton rise compared with the commencement of this year. Coir rope was fairly active during the early part, and later on Government orders having to be filled, prices for the bigger sizes have considerably hardened, and the market has practically been cleared of all foreign rope at some £1 to £2 per ton rise, and the article is still in demand. Mattress fibre has been a disappointing article, with little fluctuation in prices, all forward contracts having been fulfilled. There is a heavy stock, and prices remain without change."

Animal Bristles.—The bristles and hair obtained from the skins of animals have been much used in brush-making, but those intended for the use of artists, designers, and for certain surgical operations by medical men, require to be of the finest and most pliable texture.

The principal animals upon which we depend for bristles are the Badger, Bear, Hog, Sable, and Squirrel.

Badger, American (*Meles Labradoricus*).—The hairs of the Badger are used largely for shaving brushes.

The skins of the Badger are imported in bales from Leipsic. After washing and drying, they are cut into strips of 2 or 3 inches wide. The hairs are sorted out and the wool or downy ones are retained; the former are used for the shaving brushes, and the downy ones for other special kinds.

The hairs obtained from the skins of the English Badger (*Meles vulgaris*) are used for similar purposes. In Dec. 1901, dressed Badger hair was quoted at 55/- to 75/- per lb.

Bear, Syrian.—The hairs of this animal are several inches in length, and in general appearance resemble the bristles of the Hog, but are pliable and pendent when attached to the pelt of the animal.

Fig. 108 shows two of the hair-like bristles as seen under the quarter-inch objective. They have a deep-seated central medulla and thickened, transparent margins. The structure of the margin and central portions of these hairs, as thus seen, indicates some felting features.

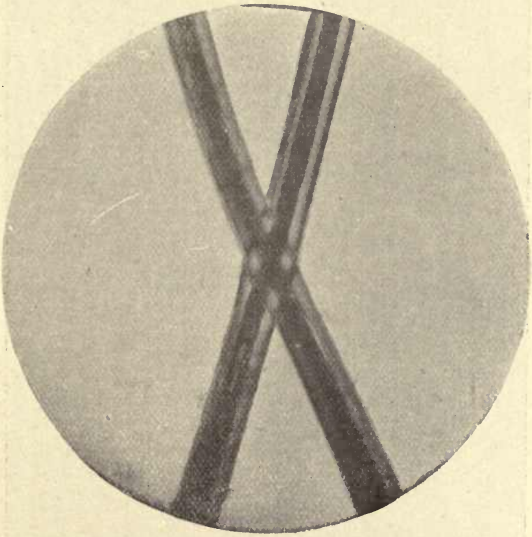

Fig. 108.—Hair of Syrian Bear.

Hog Bristles (*Sus scrofa*).—These are largely imported from Russia in their rough state. They are then sorted and classified; the longest, finest, and straightest are used by shoemakers. At one time cobblers used these bristles for stitching purposes under the name "Tatching ends," which were retailed at three or four for a penny, and are now sold at 6d. to 8d. per quarter-ounce.

Bristles are used for making long rotatory brushes used by hair-dressers, and some of the softer bristles are convenient for the brushes used by painters. Substitutes are inferior to natural bristles.

Fig. 109 represents a few Hog bristles, showing their cylindrical character with bulbs at their bases.

At Leipsic in Saxony and St Petersburg in Russia the great bristle fairs are held once or twice a year. The great woodland ranges of Russia, North-Eastern Europe, and particularly of Siberia, are the important districts from which the bristles of the swine are brought to the fairs. Bristles are also shipped from India and China to London.

The colder climates produce the hardest bristles, and the warmer districts softer in proportion.

The finest or smallest bristles are not readily adapted for shaving or other brushes, and some are utilised for upholstery purposes.

Fig. 109.—Hog bristles.

Sable (*Mustela zibellina*).—The fur from the skin of the Sable is much used by painters, and by designers of textile fabrics for point-paper designs in Jacquard or fancy brocades, damasks, and leno or gauze goods.

Sable fur has a peculiar stiffness, and when the hairs are made into fine designers' brushes they are readily adapted to fill up the small squares of point-paper with vermilion, red, and various other colouring matters used by textile designers in the fancy weaving trade.

Squirrel or Calabar (*Sciurus vulgaris*).—The skins of the squirrel are always in demand for ladies' and children's wear. They are imported under the commercial name of Calabar.

The fur or hair from the squirrel's tail is used for artists' pencils, and many of the camel-hair and other fine brushes sold under that name are made from it.

There are various species of squirrel, which produce the grey, black, and the American red squirrel fur chiefly used as fancy furs.

ANIMAL FIBRES.—SILK.

This is the product of the silkworm, the cultivation of which has been carried on from a very early period, several centuries, indeed, before the Christian era.

The principal silk used for commercial purposes is a material obtained from the larva or worm of the silk-moth.

The fibre is contained in the cocoon, the protective covering of the pupa, which is the intermediate stage of the development of the actual silk-moth.

The larva or caterpillar of the silk-moth feeds on the leaves of plants, more particularly on those of *Morus alba*, or white mulberry tree. When the larva has attained its full period of growth, it ceases to eat for a time and remains quiet, during which period the silk and cocoon become the temporary home of the pupa.

The silkworm or caterpillar possesses two glands, one on each side of the head. When the caterpillar has finished eating, a fine silk commences to exude from the glands, and the upper part of the body and head is moved forwards and round, the silk being left in the path of the circuit taken, and the deposition of silk continued until the cocoon is completed. The larva then passes into its pupa stage.

The cultivation of the silkworm dates back to remote antiquity, viz., about 2640 B.C. The Empress of China, Se-ling-she, gave encouragement to the rearing of the insect and the planting and growth of the mulberry tree. Its culture spread to Japan, India, and Central Asia.

The cultivation of silk in England commenced about 1585, when a body of Flemish weavers settled at Spitalfields in London, and initiated the silk-throwing industry of that locality.

Royalty encouraged it. James I. extended and promoted the culture of the mulberry and silkworms, and a company was incorporated as the British and Colonial Silk Company, with a capital of £1,000,000, for its cultivation in Ireland. This, however, proved to be a failure.

In 1838 Mr Samuel Whitmarsh introduced the culture of silk into America from the *Morus multicaulis*. Plantations were set up in Pennsylvania, and speculation became rife.

This species of silkworm turned out a failure.

The Lepidoptera (or scale-winged insects) is the group to which the silkworm belongs, and *Bombyx* is the generic name. The principal species for the production of silk is the *Bombyx mori.*

There are several species of silk-moth in India that feed on the mulberry. These include *Bombyx textor*, known also as the Coropooloo, which produces a soft, silky cocoon. *B. sinensis* is the Chinese silkworm, which produces a soft cocoon. Another is known as the Burmese silkworm, or *Bombyx Arracanensis.*

The Chinese Tussur silkworm feeds principally on the leaves of species of oak (*Quercus*). *Antheræa mylitta* builds a peculiar hard-looking cocoon; it hangs supended from a twig by a terminal appendage of the outside of the cocoon. The cocoon is oblong in shape, with wrinkled and striated markings, and has a silvery grey colour. Nearly all the Tussur silk of commerce is from this species of silkworm.

The Japanese silkworm is the *Antheræa yama-mai.* This also feeds upon the foliage of the oak when obtainable. Unfortunately the Yama-mai silk-moth goes through its larval or feeding stage at a time when the oak tree is almost destitute of foliage, or while the leaves are not sufficiently matured for the silkworm to feed upon.

Other silkworms which produce wild silk are the caterpillars of the Atlas moth—*Attacus atlas*, which is almost restricted to India, China, and Java; *Attacus cynthia*, reared as a domestic species in China, whose larva feeds upon the leaves of the "Tree of Heaven," *Ailanthus glandulosa*, and *Attacus ricini*, whose larva feeds upon the segmental lobed leaves of the Castor Oil plant (*Ricinus communis*). The cocoons vary in colour from orange red to white.

The weight of the individual cocoons varies from 16 to 50 grains. The outer protective part of the cocoon is of a hard gummy substance; it is termed the *husk* or *knub.*

The silk fibres are made up of two outer transparent or double parts, termed the *bave.* It is the reelable portion, and in some cocoons it will reach 700 yards, in others 4000, and in some only 300 yards.

According to Sir Thomas Wardle the bave portion of the fibre measures on an average $\frac{1}{900}$ to $\frac{1}{1000}$ inch at the thinnest, and from $\frac{1}{700}$ to $\frac{1}{800}$ inch at the thickest part. In some specimens the middle length is one-third thicker, stronger, and more elastic than the ends.

The central part of a silk fibre is the *core* or *fibroin.* The fibre is coated with albumen and a waxy colouring matter. This fibroin has the appearance of pure silk. It is brilliant, soft, and of a pearly lustre. Its chemical formula is $C_{15}H_{23}N_5O_6$. The coating of the fibre is gelatinous and gummy; its formula is $C_{15}H_{25}N_5O_8$.

It has been stated by P. Bolley that the glands of the silkworm contain semi-liquid fibroin alone, and that on exposure to the air the surface is acted upon by oxygen, transforming the external pellicle into the more soluble form of sericin. Silk will readily imbibe water; the fibre being so hygroscopic as sometimes to take up 30 per cent. of moisture.

Silk fibres may be distinguished from others by curling up when exposed to a flame, and by giving off the characteristic odour of burning nitrogenous matter. A solvent for silk is a concentrated solution of zinc chloride, 138° Tw. (sp. gr. 1·69), made neutral, or boiled with excess of zinc oxide. The silk dissolves slowly if the solution is cold, but rapidly if heated, forming a thickened gummy liquid.

Silk Industry.—The merits of the silk industry are referred to by Sir Thomas Wardle as follows:—"We are in our sericultural wealth, through having India, more than equal to France, Italy, or any other country in the world, being in some respects better off than China, for we are not confined to one species of silk, nor to two. India can boast of the greatest silk-producing fauna in the world. She has her varieties of Bombycidæ, which feed on the mulberry leaf, both wild and domesticated; she has her jungle broods of worms of many sorts, more or less useful or to become useful by and by; her Tussur silk is now an established and well-rooted industry, a few years ago in export non-existing; her Assamese women are clad in silks of the Eri and Muga worms, of which as yet we know practically nothing, and silken stuffs are handed down from matron to spinster but little the worse for the wear of a generation."

Topography and Remarks.—The production of silk is carried on as an industry to a large extent in Italy, Turkey, and Greece, also in France, Spain, Japan, and Portugal. In all the countries mentioned it is cultivated and spun into yarns, or woven into the most elaborately figured and lustrous of fabrics. In many countries the cultivation of silk is not only carried on by private firms, but subsidies are also granted by the government to encourage it.

Silk Fibre Texture.—In a report of the silk section at the Manchester Exhibition, Sir Thomas Wardle gives particulars of a mulberry-fed silkworm cocoon (*Bombyx mori*), raised by G. Thorne, Castle Hill, Paramatta District, New South Wales. Description of the cocoon and its silk fibres:—Form, elliptical oblong, with slight medial depression. Colour, light buff outside but yellow inside. Texture rather loose, the silky walls of the cocoon being composed of successive layers. The reelable cocoon thread or bave is composed of two cylindrical fibres or *brins*, consisting of homogeneous matter (fibroin, *Schorlemmer*) surrounded and cemented together by a substance resembling gelatine (sericin or silk-gelatine, *Schorlemmer*). This latter is called "gum" in England and "gres" in France.

As with other mulberry silks, the two brins polarise light very beautifully when the bave is examined with the microscope and polariscope, but the surrounding silk gelatine, which forms about 33 per cent. of the total weight of the bave, has no polarising power.

Weight of cocoon,	0·727 gramme.
Dimensions of cocoon,	35 × 19 millimetres.
Length of bave reeled,	615 metres.
Weight of bave reeled,	0·190 gramme.
Titre of bave, milligrammes per 500 metres,	154 milligrammes.
Titre of bave in deniers,	2·89.
Mean diameter of bave,	00·336 millimetre.
Mean elasticity of bave,	20·77 per cent.
Mean tenacity or strength of bave,	8·53 grammes.
Percentage of silk reeled from the cocoon,	

Table of the Diameter, Elasticity and Tenacity of the Bave—(I.) ten metres from the end at the outside of the cocoon; (II.) at the middle of the cocoon; and (III.) ten metres from the end at the inside of the cocoon.

	I.	II.	III.
Diameter of bave in ten-thousandths of a millimetre,	* 322 irregular	345	340
Percentage of elasticity, average of six estimations,	† 13·3	24·3	24·7
Tenacity or breaking strength in grammes, average of six estimations,	‡ 6·25	10·27	9·07

	I.	II.	III.	IV.	V.	VI.	VII.
Weight in milligrammes of each 100 metres of bave reeled from the cocoon, commencing at the end of the bave, which is at the outside of the cocoon,	31	35	34	32	32	26	15 metres remained.

* 322 ten-thousandths of a millimetre = $\frac{1}{789}$ inch, as will be seen from the following calculation:—$\frac{1}{10,000}$ millimetre = 0·000003937 inch, ∴ $\frac{322}{10,000}$ millimetre = 0·001267714 inch or $\frac{1}{789}$ inch.

† *I.e.*, 100 inches of bave will stretch or extend, before breaking, to 113·3 inches.

‡ 6·25 grammes = 0·2204375 oz. avoirdupois, by the following calculation:—1 gramme = 0·03527 oz., and 0·03527 × 6·25 = 0·2204375.

The diameter and strength of the bave, or natural pair of fibres, are, of course, double those of the single fibre or brin.

TABLE of the Diameter, Strength, and Tension of a Single Cocoon Thread or Bave, and Dimensions of Cocoons of the chief Mulberry and Indian Wild Silks. By Sir Thomas Wardle, F.G.S., F.C.S.

Name of Worm or Silk.	Country.	Diameter of Single Fibre in Fractions of an Inch.		Tension or Limit of Stretch before Breaking, in Inches, of Single Fibre One Foot Long.		Strength of Single Fibre in Drams Avoirdupois.		Dimensions of Cocoon in Inches.
		Outside of Cocoon.	Inner Part of Cocoon.	Outside of Cocoon.	Inner Part of Cocoon.	Outside of Cocoon.	Inner Part of Cocoon.	
Bombyx mori, or Mulberry silk,	China	$\frac{1}{1920}$	$\frac{1}{1400}$	1·3	1·9	$1\frac{5}{8}$	$2\frac{5}{8}$	$1\frac{1}{8} \times \frac{1}{2}$
	Italy	$\frac{1}{1900}$	$\frac{1}{1480}$	1·2	1·9	$1\frac{7}{8}$	$2\frac{5}{8}$	$1\frac{1}{4} \times \frac{5}{8}$
	Japan	$\frac{1}{1740}$	$\frac{1}{1440}$	1·2	1·4	2	$3\frac{1}{8}$	$1\frac{1}{8} \times \frac{5}{8}$
Bombyx fortunatus,	Bengal	$\frac{1}{2200}$	$\frac{1}{1950}$	1·8	2·3	$1\frac{5}{8}$	$2\frac{3}{4}$	$1\frac{1}{4} \times \frac{1}{2}$
Bombyx textor,	India	$\frac{1}{2400}$	$\frac{1}{2100}$	1·5	1·9	$1\frac{3}{8}$	$2\frac{5}{8}$	$1\frac{1}{4} \times 1\frac{1}{2}$
Antheræa mylitta, or Tussur silk,	India	$\frac{1}{620}$	$\frac{1}{580}$	1·9	2·7	$6\frac{5}{8}$	$7\frac{3}{4}$	$1\frac{1}{2} \times \frac{7}{8}$
Attacus ricini, or Eria silk,	India	$\frac{1}{1170}$	$\frac{1}{1070}$	1·7	2·0	$1\frac{1}{2}$	3	$1\frac{1}{2} \times \frac{3}{4}$
Attacus cynthia, or Ailanthus silk,	India	$\frac{1}{1200}$	$\frac{1}{1030}$	2·6	2·9	$2\frac{3}{8}$	$3\frac{1}{2}$	$1\frac{3}{4} \times \frac{3}{4}$
Antheræa assama, or Mugar silk,	India	$\frac{1}{780}$	$\frac{1}{800}$	2·4	2·9	$2\frac{7}{8}$	$4\frac{7}{8}$	$1\frac{3}{4} \times 1$
Actias selene,	India	$\frac{1}{1000}$	$\frac{1}{920}$	2·0	2·8	$2\frac{3}{8}$	4	$3 \times 1\frac{1}{4}$
Attacus atlas,	India	$\frac{1}{980}$	$\frac{1}{900}$	1·9	2·8	$2\frac{1}{8}$	$4\frac{1}{8}$	$3\frac{1}{2} \times \frac{7}{8}$
Antheræa yama-mai,	Japan	$\frac{1}{1130}$	$\frac{1}{1040}$	2·0	4·0	$6\frac{3}{4}$	$7\frac{1}{2}$	$1\frac{1}{2} \times \frac{7}{8}$
Cricula trifenestrata,	India	...	$\frac{1}{830}$	...	...	...	...	$2 \times \frac{3}{4}$
Antheræa pernyi,	China	$\frac{1}{760}$	$\frac{1}{720}$	2·0	2·7	$3\frac{1}{4}$	$5\frac{7}{8}$	$1\frac{5}{8} \times \frac{3}{4}$

Entomologists have distinguished a good many species of silk-moths whose larvæ, after feeding up, protect themselves by a continuous silky thread spun into a covering of an oblong shape which completely encloses the caterpillar. This outer covering has been termed the cocoon.

The world's produce of animal silk is dependent upon the amount that is contained in the cocoons of the cultivated species of silkworms. Wild silks are the product of the cocoons that have been produced by feral silkworms.

The most valuable silk of commerce is that produced by the silkworm of *Bombyx mori*. The specific name signifies that the caterpillar feeds upon the leaves of the mulberry tree. When pressed for food, the insect will feed upon the leaves of the garden lettuce (*Lactuca sativa*), but the silk produced is of an inferior quality.

The outer covering of the cocoon is composed of a kind of fluffy silk sometimes termed *floss*; this is used as spun silk, and forms an important and separate branch of the silk industry under the name of *waste silks*.

The cocoons which have a hard and firm covering are regarded as the most valuable, as they contain the greatest quantity of silk, while those which are soft and thin are regarded as inferior in quality.

There are several stages in the life of the silkworm. The first is the egg stage, in which the eggs laid by the female moth are segregated on the leaf or other material, to which they adhere by an adhesive substance.

The eggs are very small and exceedingly light. They have been compared in size and shape to the seeds of the Opium poppy (*Papaver somniferum*).

The second or caterpillar stage commences immediately the eggs are hatched. The caterpillars at first are very small, barely more than a quarter of an inch in length. They readily commence feeding on the fleshy parts of the leaves, leaving the veins almost untouched. The body of the caterpillar grows, and the skin covering is renewed several times, to allow for the increase in size, until the larva ceases to eat.

The third stage is marked by the spinning of the silk fibre from the two opposite glands known as the sericteria.

The fourth stage is the chrysalis or pupa, which results from a metamorphosis of the larva in the inside of the cocoon. After a period of rest, if undisturbed, it emerges from the cocoon as a fully-developed moth, after having softened a portion of the cocoon. This softening interferes with the commercial qualities of the silk, and to avoid it the cocoons are heated in an oven to about 60° to 70°, or immersed in a steam box, which has the effect of killing the pupa or young moth in about ten or twelve minutes.

The steaming of the cocoons has the effect of softening the silk coating and causing the fibres of the cocoon to adhere together.

The cocoon of the female is of an oval shape, and that of the male is more of a dumbbell shape.

Fig. 110 is a photograph of *Bombyx mori* showing the oval cocoon; the eggs laid by the moth in fair quantity, but not adhering together; also the annulated caterpillar feeding upon the oval leaves of the mulberry plant. At the bottom of the illustration is the chrysalis or pupa, of an elliptical or oblong shape, conical at one end and rather obtuse at the other, and having a horny and annulated exterior. (This photograph is reduced from a drawing in Cassell's *Technical Educator*.)

From the cocoons of *Bombyx mori* is obtained the ordinary raw silk of France, Italy, China, Japan, and India. The mulberry plant is not much cultivated in England, but grows chiefly in other countries. The *Morus alba*, or White Mulberry tree, is a native of China. It was introduced into England in 1596. At one time a number of plants of the species *alba* was introduced into Ireland, with a view to the culture of silk in that country.

The *Morus nigra*, or Black Mulberry, is a native of Italy, and was introduced into England in 1548. Both species of mulberry are related to the nettle, and are now placed in the Natural Order *Urticaceæ*, sub-order *Moraceæ*.

Fig. 111 shows three cocoons of *Bombyx mori* from Italy, all of different sizes and shades of colour, varying in shape from an oval to an oblong form with rugose surfaces.

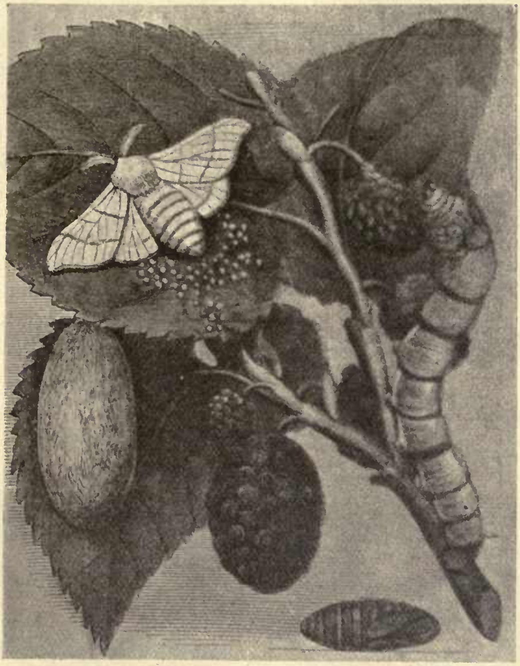

Fig. 110.—*Bombyx mori.*

In the upper case is a perforated cocoon of the *Cricula trifenestrata* of Java and India. For the specimens in this illustration I am indebted to the late Alderman John Thorpe of Middleton.

Attempts at crossing the *Bombyx mori* with other silkworms have been made, and crosses have been effected between *Bombyx crœsi* and *mori* with very good results.

Fig. 112 shows the *Antheræa mylitta* cocoon, which is of an oval shape and of a dirty greyish colour.

This silkworm produces the Tussur silk of India. These cocoons are generally suspended from the twigs of trees by a hard pedicle, which is shown in the illustration. Another cocoon is shown in longitudinal section, cut open in order to show the pupa or chrysalis inside.

The cocoon is about the size of a plum, and nearly similar in shape to that fruit. The larva or caterpillar is about two inches in length when full grown. The annulations or joints of the larva are about seventeen in number, spongy in form, with tufts of stellate hairs.

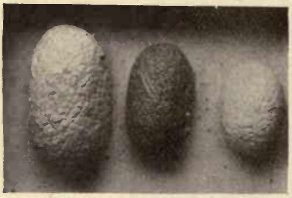

Fig. 111.—Cocoons of *Bombyx mori* and of *Cricula trifenestrata.*

Fig. 113 shows three of the fibres of *Antheræa mylitta* with a longitudinal groove running down the centre. The groove does not actually separate the two portions of the fibre.

The illustration is a photo-micrograph of three silk fibres of *A. mylitta* as seen under the quarter-inch power of a good microscope.

The two outer coatings of most silk fibres are specially adapted for absorbing brilliant dyes; the fibres are tenacious and glossy, and lend brilliancy to the surface or face of silk fabrics.

The Tussur silkworm chiefly feeds on the leaves of the *Terminalia tomentosa.* The leaves of the plant are elliptical, acute, with a pinnate

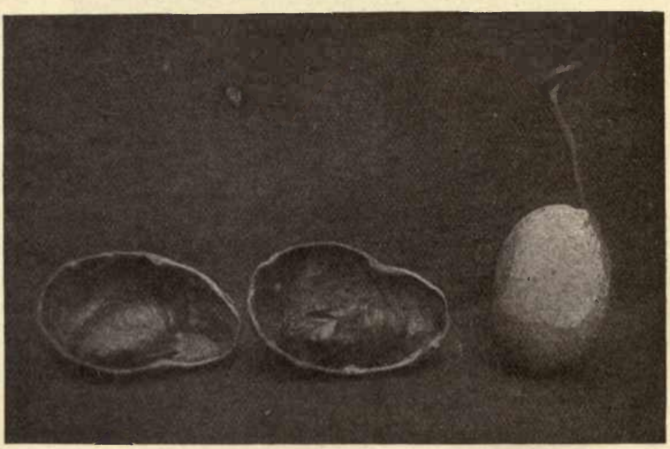

Fig. 112.—Cocoons of *Antheræa mylitta.*

venation. They grow in tufts at the ends of the stalks; hence the name of the genus, *Terminalia.* The Tussur silkworm also feeds on *Terminalia Catappa,* a broader-leaved species with obovate leaves, blunt at base and downy on the dorsal surface. Other plants which the Tussur feeds upon include *Shorea robusta*, the Teak tree, *Tectona grandis*, and *Bombax heptaphyllum*, the seven-leaved Silk-Cotton tree, a native of America, and belonging to the Natural Order of plants Sterculiaceæ.

Fig. 114 shows the caterpillar, the moth, and the ragged-looking cocoon; also the food of the *Bombyx* or *Attacus cynthia*. This silkworm produces a silk noted for its extreme softness. It is a native of India. Its cultivation is largely carried on in China, Java, and in

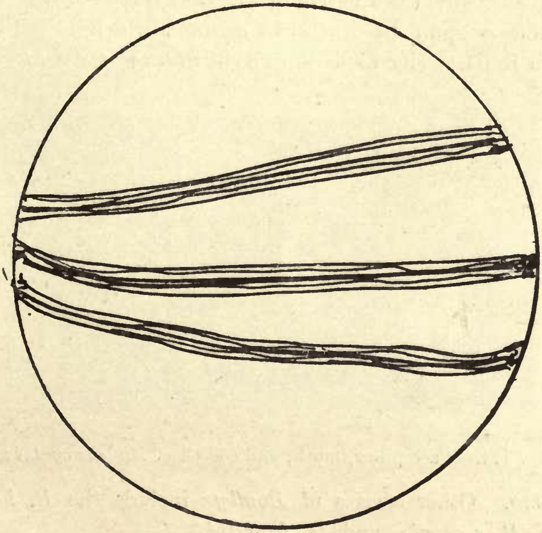

Fig. 113.—Fibres of *Antheræa mylitta*.

Southern Europe. It produces a long greyish cocoon, which hangs suspended from the twigs of trees.

Another species, the *Ailanthus excelsa*, has compound bipinnate leaves, with ovate, acute, serrate margins. This species is a native of the East Indies, and was introduced into this country in the year 1800. It also serves as food for *Bombyx* or *Attacus cynthia*.

Cocoons.—In the illustration, fig. 115, are four cocoons. (1) is that of *Antheræa mylitta*, showing in this specimen an outside glossy covering of a brown colour when photographed.

(2) is that of *Antheræa yama-mai*. This was smaller, and the specimen had a green flossy surface when photographed. It is the Japanese silkworm of commerce, and produces a good silky fibre, which has been much used by the Japanese for embroidery purposes.

(3) is the cocoon from the *Antheræa pernyi*, a silkworm feeding on

the oak. The cocoon is furnished with a pedicle, and was of a light brown colour when photographed. The insect is known as a Tussur silkworm.

(4) shows a variety of the cocoon of the *Bombyx mori*. It is made up of two smaller cocoons of a yellowish colour. For these specimens of cocoons I am indebted to Mr. J. T. Taylor, of Manchester.

Bombyx fortunatus feeds on *Morus indica*, whose leaves also form the food of *Bombyx textor*, *B. meridionalis*, and *B. sinensis*. *Bombyx ricini* feeds on the peltate, palmate, simple leaves of the well-known Castor Oil plant, which is a native of the East Indies.

Muga silk is spun by *Antheræa assama*, which is indigenous and cultivated in India. The food of this silkworm is the leaf of *Machilus*

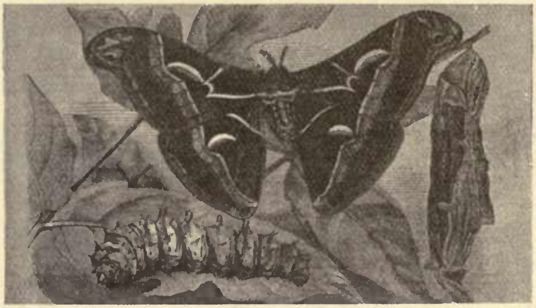

Fig. 114.—Caterpillar, moth, and cocoon of *Attacus cynthia*.

odoratissimma. Other species of *Bombyx* include the *B. hesperus*, *B. polyphemus*, *B. cecropia*, and *B. fauretyi*.

Antheræa paphia is a native of Darjeeling in the Himalayas. It produces a large quantity of silk, which is collected by the natives in the jungles. This silkworm exercises some ingenuity in the building of its cocoons, which are rolled up in the leaves and so resemble the true leaves as to be difficult to distinguish, affording, certainly, a good example of mimicry of foliage leaves.

The silk from *A. paphia* is regarded as the true Tussur. It is easily wound off from the cocoons, like that of the ordinary silkworm.

Under the generic name of *Antheræa* a large number of species of wild silkworms is included, particularly *A. Perrottetti*, *A. Roylei*, *A. Jana*, *A. Frithii*, and *A. Larissa*. All these are known as Tussur silkworms or moths. Among other genera and species of silkworms may be mentioned *Saturnia pyretorum* and *S. grotei*. Among the plants which are selected as food by *Antheræa* and some other genera may be mentioned *Berberis asiatica*; the sensitive plant *Mimosa*; the Plum tree, *Prunus*; the Evergreen Oak, *Quercus Ilex*; and *Prunus Padus*, or the Wild Bird Cherry.

Dr. Wallace, dealing with the qualities of the cocoons, says: "There are nine different qualities.

"1. *Bons cocons* (good cocoons), which have been brought to perfection. These are by no means always the hardest, but are compact, free from spots, and of a good shape.

"2. *Cocons pointus* (pointed cocoons) have one extremity rising in a point. These, after affording a little silk in reeling, break or tear at the point, where the thread is weak, and they cannot be wound further, as

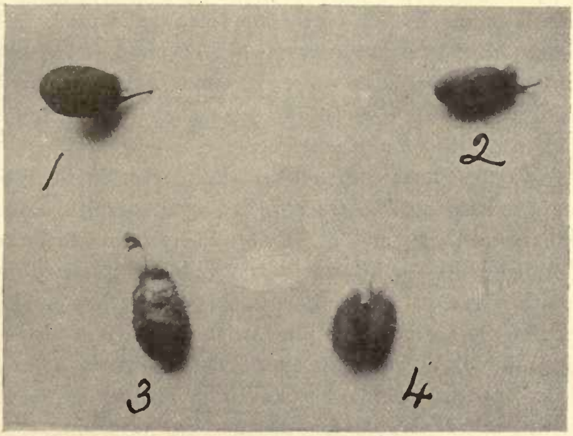

Fig. 115.—Silkworm cocoons.

the fracture would occur as often as the thread reached the weak point.

"3. *Cocons foibles* (weak cocoons) are rather larger than the regular cocoons, but do not contain more silk, their texture being less compact. These are separated from the other kinds, because in reeling they must be immersed in colder water in order to avoid any furzing or entangling in the operation.

4. *Cocons doubles* (double cocoons).—The threads of these are so mixed that frequent breakings occur in reeling, and often they cannot be reeled. In any parcel the proportion will reach from 1 to 5 per cent., which is the highest allowed without reduction in price.

"5. *Cocons satines goufflons* (flossy cocoons). — These are very imperfect cocoons with a loose texture, sometimes to such a degree that they are transparent. These cannot be reeled.

"6. *Cocons ouverts* (perforated cocoons), as their name denotes, have a hole at the end, generally from the moth having escaped. They cannot be reeled in the ordinary method, as tbe thread always breaks when it arrives at the perforated place. Latterly, however, it has been found that the moth does not rupture the threads, but only separates and pushes them apart during the act of emerging, having previously liquefied the gum which bound the threads together by means of the alkaline fluid emitted from the face, and attempts have been successfully made to adapt machinery to their reeling.

"7. *Chiques, cocons chiques* are cocoons wherein the insects have died before completing their task. These are known by the adhesion of the worm to the cocoon, which prevents it rattling when shaken. The silk of these is as fine as that of the first-mentioned quality, but not so strong nor so brilliant; and they must be wound separately, as they sometimes furze in reeling.

"8. *Cocons taches* are defective cocoons, spotted or rotten. They furnish foul, bad silk of a blackish colour.

"9. *Dragles* (calcined cocoons) are those wherein the worms, after having completed their cells, are attacked by a peculiar disease which sometimes hardens them, and at other times reduces them to a white powder, a fungoid disease known by the name of *muscardine.* In the former case they are called comfit *cocoons*, from the resemblance borne by the withered worm to a sugar plum. The quality of the silk, so far from being injured, is generally excellent, and it is even in greater quantity than in the cocoons of healthy worms. Comfit cocoons may be distinguished also by the peculiar light, rattling sound of the dead worm within. They are much esteemed and fetch a high price, but are not of frequent occurrence. Three lbs. of fresh or green cocoons will make 1 lb. of dried cocoons, and about 4 lbs. of dried cocoons will produce 1 lb. of reeled silk. It therefore takes about 12 lbs. of fresh cocoons to produce 1 lb. of silk."

Sericiculture.—In a recent article in the *Society of Arts Journal*, it was stated that "In Germany, for some years past, efforts have been made, and with considerable success, to acclimatise the oak silkworms of China and Japan—*Attacus pernyi* and *Attacus yama-mai.* They have been raised in the open air, protected from the attacks of birds by nets of gauze or wire, changed from place to place as the oak leaves are consumed. Late frosts and excessively dry weather have been injurious in depriving the worms of food. In California, a new wild silk-moth, before unknown, has been found thriving on the poisonous species of *Rhamnus californicus* or *R. purshianus.* It produces a silk as good as that of the domesticated Bombyx. Owing to the favourable nature of the climate, without the frosts or rains of China and Japan, great hopes are obtained of propagating this species. In Yucatan a wild moth has also been met with, somewhat allied to the mulberry worm, which produces silk of a bluish tint, but the gum which envelops it is difficult to remove.

"Mr. John MacIntyre, a recent traveller in Manchuria, records having met with several new species of silkworm, which he describes in the *Chinese Times.* One wild worm feeds on the *Pinus chinensis.* It forms handsome cocoons, which yield a strong silk, but they are so mixed up with the needle-like leaves of the pine, that the winding of the silk would be difficult. On the walnuts he found another, which forms a reticulated cocoon, like a Chinese lantern. He also met with two other species of mulberry worms, one very hardy, which could be fed on lettuce or dandelion leaves, and remains stationary, the other which moves easily from branch to branch in search of food. The rearing of *Attacus òrizaba* of Mexico is to be attempted in France."

Schappe Silk—This is known also as spun silk. In the operation of reeling the silk from the cocoon there is often some that has become disarranged or entangled in such a manner as to prevent its being reeled in the ordinary way. In some cocoons, where the cultivation of silk is carried on extensively, the moth is allowed to emerge, for the purpose of promoting a good breed or reproduction of silkworms at a later stage of the industry. The cocoons from which the moth emerges have their threads displaced. This silk is collected with the waste obtained from the various processes, such as winding, twisting, etc. This waste material is utilised for weaving fringes and for the production of sewing silks of remarkable lustre.

Tram and **Organzine.**—The above terms are generally adopted to indicate the longitudinal and transverse threads of silk that are used to build up the structure of a woven fabric. A union cloth of cotton and silk, where the former is the warp and the latter the weft, as in a Barathea cloth, would have a backbone of cotton, and a floating and intersecting tram or weft, that would give a glossy effect to the fabric.

Tram is composed of one or more single threads free from twist, that are united in one operation; later, they are twisted together and form an individual solid thread known as tram silk.

The fibres of organzine become the potent factors of strength in the warp of the silk woven fabric. Several threads are individually twisted in one direction, after which they are doubled and retwisted. The twist imparted to the yarn or organzine adds strength to the fabric, but an excess of twist is a disadvantage; it reduces the glossiness or lucidity, and the selling price of the silk material is affected prejudicially. As the organzine or warp threads have to withstand the greatest amount of strain during the process of weaving, it becomes necessary to select the best of the cocoons that will give strong and lucid fibres to form a compact warp.

Silk, China.—The culture of silk in China has received considerable attention from Mr. E. H. Parker, British Consular Agent at Chung-king, who has written a work entitled *Up the Yangtze in 1891*, in which he says:—"Kia-ting and Pao-ning are (together, however, with Shun-K'ing) the most productive silk districts. The Kia-ting silk comes first in quantity, and being mostly white takes the dye best. The fine silk, however, comes in larger quantities from Shun-K'ing and Pao-ning, where the yellow cocoons yield a thicker thread. The value of the combined production of the two latter prefectures is estimated by competent native authorities at from £204,000 to £306,000 a year, against from £408,000 to £612,000 for Kia-ting. The same authority estimates the production of Y'en-shon, where the silk is celebrated for its superior quality, at £40,000 a year.

"Most places in Szechuen produce silk for local consumption, and the places named are only local centres whence considerable export takes place. Little or none is produced in Chung Ch'ang or Lung Chung; little again in Nan Ch'uan and only mountain silk in K'i Kiang; but most places have a little. In the small districts of Pi'chan, for instance, there is a production of from £2000 to £4000 worth of silk in the year. The whole business is transacted in twenty successive days, at twenty different market towns.

"The export of Szechuen silk was, within the last two years, carried on almost entirely by hand. It is carried either to Hankow or, by way of Shih-nan, to Sha-shib, whence it travels *via* Sui-ting and Tung-hsiang or *via* King-men and Fan-Ch'eng, to Pekin and the north generally. From Hankow the silk is carried by steamer to Shanghai, and thence to Soochow, where it is often dyed and sold as Soochow fabric.

"Silk-dyeing used to be done much better both at Pekin and Soochow than in Szechuen, but now it is extensively carried on with aniline dyes, more especially at Chêngtu. . . . . The trade with Canton, which place formerly took 600 to 700 boxes a year, has dropped, but both the hwo-sz and the shin chang-sz, mentioned by the Shanghai delegates of the Chamber of Commerce, have resumed their place in the export to Yünnan, which province takes also large quantities of silk thread. Silk is also exported to Kwei Chou from Chung-king.

"The season covers the third and fourth moons (April and May), and is quite over in the fifth and sixth moons (June and July). . . . . In Kia-ting the silkworms are frequently fed at first with the leaves of the chê, or silkworm oak, which resembles somewhat the leaves of the chrysanthemum. As they grow older, the diet is changed to mulberry leaves. This is 'hard silk,' and none of it is found in Pao-ning or Shun-K'ing. The worms which produce the wild silk of Kwei Chou are fed on the young leaves of the ch'ing kang, a species of Quercus. These two trees must therefore be closely allied. . . . . The fabric made from the wild silk, or shan-sz, is also called kê-ta chow, from the lumps and nodules which are found in its coarse texture.

"The newly-hatched grubs must be fed daily with clipped leaves, and the leaves must be changed three times a day. There must be no lime or dirt upon them, and they should be carefully wiped with a damp kerchief. Everything near the silkworms must be kept scrupulously clean. After ten days they have grown to the size of a caterpillar and developed their eight legs. When mulberry leaves have not been used from the beginning, this is the time for substituting them for the leaves of the silkworm oak. After a month, again, the worms begin to make nests on the stalks, form an egg [cocoon] around themselves, and begin to disgorge silk. As soon as they cease to move, they are removed from the branch.

"A certain number of insects are allowed to live, in order to produce eggs for the succeeding year. The grub comes out of the cocoon in the fourth moon (May) and lays its eggs upon sheets of paper provided for that purpose. These sheets are carefully placed in boxes and hung up in a dry place in the house until the first moon (February) of the ensuing year. On the arrival of the solar term Ching Chih, or 'movement of larvæ' (about March 5), the sheets of eggs are taken out of the boxes and carried about in the hat or bosom, or placed among the bedclothes, in order to be hatched. Sometimes they are placed, instead, in a sort of large basket or sieve, which is kept in a warm place.

"In washing the silk, or wetting it in order to wind it from the cocoons, the Chinese do not put potash and the caul of pips into the water, as has been supposed by some. These ingredients are, however, used to make silk glossy in the weaving. The term 'Kwo-p'ên' is used to indicate silk which has undergone more than one washing, or in the washing of which more than one pan or basin is used. All silk must pass through at least one basin of water, so that the definition, given by the delegates, of 'Kopun, so called from its passing through the basin in reeling," is hardly correct. As the Szechuen washers are paid according to the number of cocoons they can get through, the rate being 4¼d. per ton or peck, no pains whatever are taken to keep the thread at a uniform thickness. Instead of taking up the ends of five cocoons, as is done by women in Soochow, the workmen frequently grasp as many as thirty.

The water in which the cocoons are placed must be very hot, otherwise the insect changes into a moth.

"The winding operations of silk are carried on in the following manner:—

"A woman sits on a bar of a very simple oblong frame, just wide enough to contain her legs and allow free movement. In the middle, running parallel with the long side of the frame and equidistant from each of the short sides, is a treadle about 2 feet long and 6 inches broad, like a double pedal of a piano. Through the middle of this treadle runs a stick about 3 feet high, and, as the woman plays with each foot upon the two sides of the treadle one after the other, of course the stick wags from side to side. To the top of the stick is affixed another stick about half as long as the frame and running parallel with its long side. At the other end of this last-named stick is fastened the outer end of a zigzag piece of wood or an iron crank, the inner end of which fits into a wooden roller about the size of a large bread roller. This roller is the axle-tree of a six-spoked wheel about 2½ feet in diameter. There is a double row of spokes—that is six running out of each end of the axle—and each spoke is connected with the one opposite to it by a stick, these six sticks forming, so to speak, the felloe or tyre of the wheel.

"So far, we see that the wheel is turned when the woman presses the treadle. At the woman's right hand (the wheel being at her left) is a small stove keeping almost on the boil a gallon or two of water in an ordinary iron cooking pan, 2 feet in diameter. The frame is prolonged so that one short side ends in a bar running over the middle of the pan, and on this bar is set another frame (like a Bahl saw) having as its middle part a small roller (usually divided off into two or three separated portions) of bamboo slips. In the lower part of the small frame, on the woman's side, are fixed two or three hooks, or two or three copper coins, with suitable holes (accordingly as the rollers and wheel carry off two or three skeins), and through these hooks or holes the woman inserts five cocoon threads selected from a bundle of several dozen which she holds in her other hand or keeps hanging to a counter-balancing chopstick. The thread of five strands is thus brought through the hook or cash and a few inches above. It is then brought over the roller and back on to the circumference of the large wheel, which, when revolved, of course turns the small rollers very rapidly, but, owing to their small size, with very little jerk upon the cocoons, and the silk is wound on to the circumference of six felloe spokes of the wheel. Every second or so one or more, or even all of the strands forming the skein thread break, but the woman with great and almost invisible dexterity joins others on to those remaining attached, which are themselves almost invisible. This joining

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is effected under the hook or cash, and therefore requires no pause to pass it through the hole, unless all five break together, when she must pass a new thread up the hole. The cocoons which are attached float promiscuously about with the others, or bob about, like fishes catching the rain, just under the hooks. The skeins are about 3 or 4 inches broad, and the same distance from each other.

"The way in which the silk is distributed over this breadth, instead of becoming all ravelled in a narrow rope, is ingenious in the extreme, and I will endeavour to describe it. At the other (that is, not the crank) end of the axle is a prolongation about 4 inches beyond the spokes. This prolongation is a mere shade thicker than the rest of the axle, and is, moreover, roughened. Over this runs a wooden wheel or block about 6 inches in diameter and 3 inches in tyre thickness, the axis of which is at right angles to the axle of the great wheel. The roughness of the axle prolongation causes this block wheel both to revolve and to bob slowly and gently, the first in a horizontal and the second in a perpendicular direction, and is, in fact, a rough application of the slanting-cog principle. The axis of the block wheel in the shape of a stick runs up and supports a crutch-like top, which is often carved in the fanciful form of a canary. The canary thus goes whizzing around, and both over and to either his head or tail a lath is fastened by a nail, the other end of which runs to and fro over a small bar running parallel to the long side of the large frame. The bird is really nothing more than a small crank. At intervals of 4 inches apart in the lath are affixed tiny crutches about 4 inches high, having tops or hooks not more than an inch across. Through these tops the thread is made to run before it is attached to the large wheel; and, as the tops move 2 or 3 inches from side to side in a direction across the felloe of the wheel and parallel with its axle, of course the thread never remains in a straight line, but is wound slightly diagonally."

Fig. 116 shows a number of skeins of the highest qualities of silk, and also some of the lowest qualities that are used in commerce. For these specimens I am indebted to the late Mr. Alderman John Thorpe.

According to Mr. C. F. Cobb, silk may be distinguished from vegetable fibres by burning the fibres, when it emits a smell of burnt horn. Wool gives a similar odour. When submitted to the action of nitric acid, the fibre is turned yellow. Silk is dissolved by strong alkalies. Dilute alkalies affect it, but without solution; ammonia has no action on the silk fibre. Schweitzer's solution dissolves the silk fibre just as it does cotton. Silk, like wool, has an affinity for tinctorial dyes. A solution of zinc chloride of 1·7 specific gravity dissolves silk, but has no action on wool. The silk is reprecipitated on adding water.

When flax, hemp, cotton, and jute are mixed with wool and silk, the sample may then be boiled in an aqueous solution containing 10 per cent. of hydrate of soda; the wool and silk dissolve, while the vegetable fibres remain unacted upon. The whole is thrown upon a cotton filter, and the undissolved matter is then washed with hot water and afterwards acidulated with 5 per cent. of hydrochloric acid, to which, if the residue is black or dark coloured, a few drops of chlorine water are added. Meantime, the original alkaline filtrate can be tested for wool with acetate of lead. If a white precipitate is formed, which dissolves on stirring, silk alone is present. A black precipitate indicates wool. The

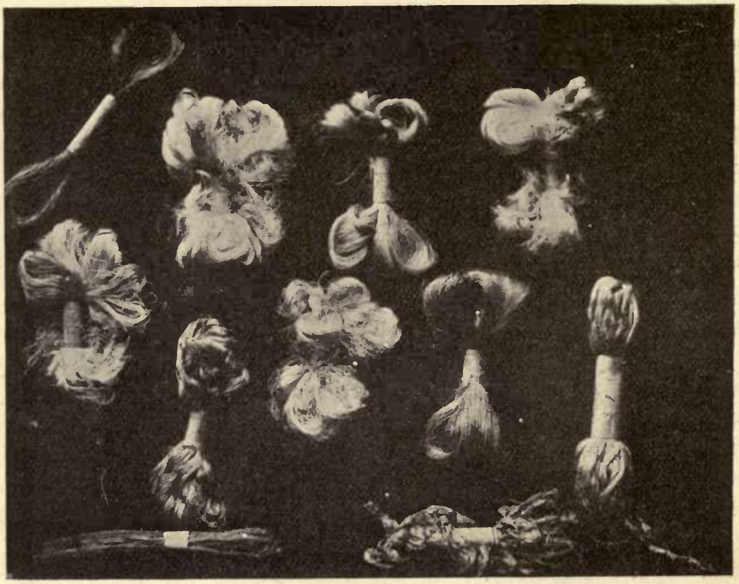

Fig. 116.—Skeins of silk.

nitro-prusside of sodium gives a violet colour if wool is present. If the tissue is deeply coloured it may be cut up and steeped for from fifteen to twenty minutes in a mixture of two measures of concentrated sulphuric and one of fuming nitric acid. Wool, silk, and colouring matters are destroyed, while the cellulose is converted into gun-cotton.

White and pale mixed tissues may be tested by their affinity for colours. They must be cleansed and rinsed thoroughly in water to remove starch and similar dressings; soaked for ten minutes at 50° C. to 60° C. in water containing 2 per cent of sulphuric acid, and washed again. In the meantime the colour bath must be prepared by dissolving a few decigrammes of magenta in 28 to 30 cubic centimetres of water, and heated to boiling. During ebullition, caustic soda must be added to it drop by drop, till a pale rose colour only remains in the liquid. The liquid must be removed from the fire, and the sample immersed in it for some minutes, after which it must be removed and dried.

Silk and wool are dyed by this treatment, while the vegetable fibres remain colourless. Wool may be detected in silk by the presence of sulphur. If it is immersed for a time in a plumbate of soda prepared by dissolving lead hydroxide in caustic soda, the silk will be colourless and the wool black; or a piece of the tissue 2 centimetres square may be

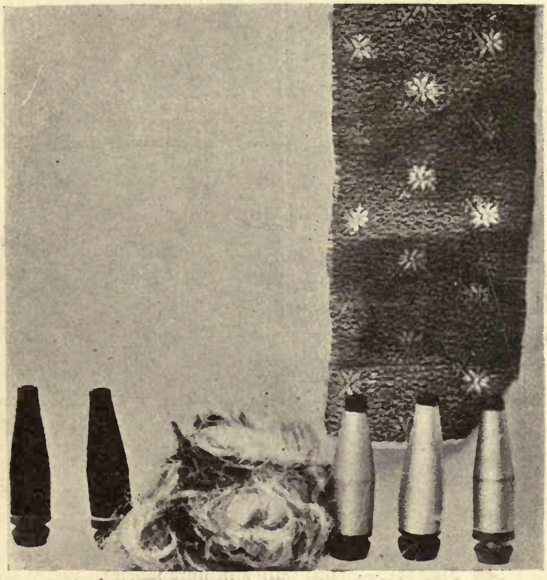

Fig. 117.—Wood pulp silk.

boiled in 10 to 12 cubic centimetres of Schweitzer's solution. In from five to ten minutes the silk will be dissolved. If the silk is black, double the volume of Schweitzer's solution should be added, and the mixture soaked from ten to twelve minutes. The undissolved wool should be then removed and the liquid quickly neutralised with nitric acid. Silk will remain in solution, while cellulose will be precipitated. Hydrochloric acid is a solvent of silk, while it leaves wool and cotton unacted upon for a lengthened period.

Sea Silk.—The marine products of the ocean have been investigated, with some success, in order to obtain a silk, independent of the silkworm culture, that may be used as a commercial article. This material has been termed *Sea Silk.* Certain marine mollusks, common on the coasts of Calabria and Sicily, attach themselves to rocks by means of stout threads. This material is combed and then treated with the juice of the lemon. Three parts of the material gives about one part of a lucid fibre of golden lustre, and from 3 to 8 centimetres long, It is of great strength, and bears a resemblance to real silk. It is made into articles such as gloves and purses.

Wood Pulp Silk.—The wood pulp silk industry has been brought to the front within the last four or five years. With the aid of a cotton warp the wood pulp silk has been woven into fabrics. The yarn from

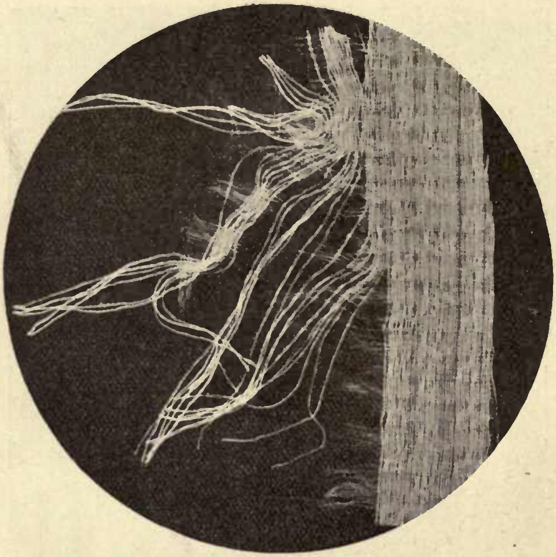

Fig. 118.—Wood pulp silk fibre fabrics.

this vegetable silk is specially prepared by some chemical method, and in appearance it has a rich glossy and silky lustre.

Fig. 117 is an illustration of the silk wound upon pirns ready for the shuttle. The two dark pirns were filled with layers of scarlet silk, and the rest with silk of a rich peach colour. The loose silk shown in the middle was of various colours and lustre. The portion of fabric shown is made of a cotton warp dyed and interlaced with the silk weft. It has a good appearance, but the strength of the weft might be much improved. If this were done, it is just possible that the wood pulp silk industry might have a good future before it. Its manufacture as a fibre is secured and reserved by patent rights.

Fig. 118 shows a piece of the wood pulp silk fabric somewhat dissected. The vertical warp threads, some of which are partly detached, represent the cotton warp, and the transversely interlaced threads are the wood pulp weft. So long as the wood pulp weft is kept intact in the fabric and not submitted to much strain, it seems to behave very well. The weft has a glossiness almost equal to some lustres of silk, but its want of strength requires to be overcome before it can be made a success. Its inflammability might also be considerably reduced.

This Wood Pulp Silk, or "Artificial Silk," to be more correct, is made by treating cotton or wood pulp with a mixture of nitric and sulphuric acid, which converts it into nitro-cellulose. This is then dissolved in a mixture of ether and alcohol. This solution is then driven through fine apertures to form a thread. The solvents evaporate away, leaving the nitro-cellulose as a silky, lustrous fibre.

The various patents of Chardonnet and Lebner are for various methods of dealing with the solution of the nitro-cellulose to obtain the fibre from it. By treatment with sulphide of ammonia the fibre can be denitrated, and so rendered much less inflammable.

WOOL.

THIS term is used to define the hairs and wool fibres of the wild and domestic sheep. These fibres serve as the protective covering to the hide of the sheep, and when made into a woollen fabric they are serviceable to be worn next to the skin.

Vegetable fibres differ in that a cotton or linen fabric worn next to the skin conducts heat, becomes moist, and keeps the skin damp and cool.

The "Jaeger" fabrics of pure wool become saturated with perspiration when worn next the skin, and this applies to all real pure wool fabrics.

The fibres of wool on the sheep's back would felt one into the other, and spoil their manufacturing properties, if it were not for their natural yolk. This yolk gives a greasy feel to the fibres. It is a natural secretion from the skin and protects the fibres from wear and injury. The yolk is most prevalent on the back and shoulders, from which the best wool fibres are generally obtained. It is essential that the yolk should be plentiful amongst the fibres. They then assume a softer appearance, the elasticity of the staple is much increased, and the fibres are better adapted, ultimately, for spinning and manufacturing purposes.

The wool fibre does not contain any cellulose substance. In this respect it differs from the cell of the cotton fibre, which is rich in cellulose and highly inflammable; wool, on the other hand, does not burn so readily, but frizzles when in contact with a flame. According to Dr. E. J. Mills, F.R.S., the chemical formula for wool is $C_{42}H_{157}N_5SO_{15}$; that for cotton being $C_6H_{10}O_5$; and that for silk, $C_{24}H_{58}N_8O_8$.

Wool that is shorn from the sheep while living is generally termed the "fleece wool." It has better felting properties than that obtained from the sheepskin after life becomes extinct. In the latter case it is often spoken of as "dead wool."

Human Hair.—The hairs on the human head are epidermal coverings to the skin of the head. They originate in a cutaneous depression, the hair follicle or bag. These hairs are not tubular structures.

The conspicuous feature of hair is the shaft or scape of the hair emanating from a bulb or root in the deep, depressed follicle of the hair. When a hair is plucked suddenly from the scalp, the bulbous part may readily be distinguished by the aid of a Coddington lens.

A single hair examined under the microscope by transmitted light shows a medullary sheath, or pith, an outer part termed the cortex, or fibrous portion, which constitutes the bulk of the hair proper. When treated with reagents the fibres become separated into cells, showing some fibrillation and nucleated structure.

In coloured hairs pigment granules about $\frac{1}{50000}$ inch in diameter are met with. Of hair in a natural state, the chief differences between that of man and of the lower animals in general are (*a*) the size; (*b*) the relative proportions of the cortical and medullary structures; (*c*) the seat of the pigment cells; (*d*) the position of the medullary cells; (*e*) the amount of tomentose down, hair, or wool; and (*f*) the size of the superficial cortical cells or scales, upon which the felting property depends.

Fibres, Cultivation and Variation.—The Character of the breed and the pasturage that is afforded to the animals have an important bearing on the wool fibres of commerce and the structural characteristics of wool produced on the different parts of the body. The uniformity of length and of diameter, and the number of scales per inch, vary in different individuals, even among the same breed of sheep. On this subject Mr. N. Burgess, of the Quekett Microscopical Club, says: "The size of the fibre is very irregular, scarcely any two forms in the same staple being found alike, and each varying in its own length.

"In a fibre of Southdown wool, a comparatively uniform species, I have found the size to vary in $\frac{1}{312}$ of an inch as much as one-fifth of the whole diameter. The finest Saxon wool I have ever seen gave a remarkable result on being measured. Five hairs in one staple were selected. The finest gave the extremely small diameter of $\frac{1}{3489}$ of an inch, while another fibre lying by its side measured the $\frac{1}{1749}$ of an inch. The mean of the fibre gave $\frac{1}{2134}$ of an inch. Another sample of Saxony wool gave $\frac{1}{2075}$ of an inch.

"Amongst Saxon wools shown in the grease two of the fibres were measured, and one gave $\frac{1}{1562}$ of an inch, while the other was $\frac{1}{1250}$ of an inch. Probably this sample could not be exceeded for beauty or symmetry. It was taken from one of Steizer's celebrated ewes.

"The Southdown sample gave for one fibre $\frac{1}{890}$ of an inch, and another $\frac{1}{520}$ of an inch. The Lincoln wool gives for one part of the fibre $\frac{1}{625}$ of an inch, and another $\frac{1}{520}$ of an inch. The coarsest fibre gives $\frac{1}{466}$ of an inch.

"The fibre of the Northumberland wool, measured in its thinnest part, gave $\frac{1}{666}$ of an inch, and in its thickest part $\frac{1}{400}$ of an inch. These examples will suffice for showing the relative degrees of size and the variations which occur in the same fibre."

Tables of Strength, Elasticity, and Diameters of Hair and Wool Fibres.

	Breaking Strain in Grains.	Elasticity in Percentage of Length.	Diameter of Fibre before Breaking in Decimals of an Inch.	Diameter of Fibre after Breaking in Decimals of an Inch.	Difference in Decimals of an Inch.
Human Hair, . . .	1680 1720	·374 ·371	·00342 ·00342	·00283 ·00283	·00059 ·00059
Lincoln Wool, . . .	580 465	·240 ·270	·00185 ·00165	·00161 ·00150	·00024 ·00015
Leicester Wool, . .	480 510	·240 ·270	·00175 ·00158	·00131 ·00138	·00044 ·00020
Northumberland Wool, ...	420 440	·224 ·300	·00143 ·00155	·00120 ·00132	·00023 ·00023
Southdown Wool, .	82 80	·230 ·210	·00101 ·00097	·00090 ·00082	·00011 ·00015
Australian Merino, .	48 46	·387 ·251	·000540 ·000472	·000354 ·000361	·000186 ·000111
Saxony Merino, . .	43 37	·321 ·263	·000317 ·000331	·000210 ·000213	·000107 ·000118
Mohair, ...	600 590	·285 ·306	·00174 ·00180	·00132 ·00142	·00042 ·00038
Alpaca, ...	150 138	·231 ·220	·000521 ·000511	·000387 ·000402	·000134 ·000109

The table just given states the minimum and maximum breaking strain and diameter of the several wools from experiments made by Dr. Bowman and given in his *Structure of the Wool Fibre.*

Sheep Classification (*Ovis*).—No classification yet proposed has met with the general approbation of naturalists. According to some there are three or four species, each represented by a number of varieties. For the purpose of this work that proposed by Professor Archer for the domestic sheep may be adopted. According to him there are 32 sub-species, of which 4 belong to Europe, 15 to Asia, 11 to Africa, and 2 to America, viz. :—

I. *Europe.*

1. The Spanish or Merino sheep (*Ovis hispanicum*).
2. The Common sheep (*Ovis rusticus*).
3. The Cretan sheep (*Ovis strepsiceros*).
4. The Crimean sheep (*Ovis longicaudatus*).

II. *Asia.*

1. Hooniah or black-faced sheep of Tibet.
2. Cago or tame sheep of Cabul (*Ovis cagia*).
3. Nepal sheep (*Ovis selingia*).
4. Curumbar or Mysore sheep.
5. Gărăr or Indian sheep.
6. Dukhun or Deccan sheep.
7. Morvant de la Chine, or Chinese sheep.
8. Shaymbhar or Mysore sheep.
9. Broad-tailed sheep (*Ovis laticaudatus*).
10. Many-horned sheep (*Ovis polyceratus*).
11. The Pucha or Hindostan Dumba sheep.
12. The Tartary sheep.
13. The Javanese sheep.
14. The Barwall sheep (*Ovis barual*).
15. Short-tailed sheep of Northern Russia.

III. *Africa.*

1. Smooth-haired sheep (*Ovis ethiopica*).
2. African sheep (*Ovis guineensis*).
3. Guinea sheep (*Ovis ammon guineensis*).
4. Zeylan sheep.
5. Fezzan sheep.
6. Congo sheep (*Ovis aries congensis*).

7. Angola sheep (*Ovis aries angolensis*).
8. Yenu or goitered sheep (*Ovis aries steatiniora*).
9. Madagascar sheep.
10. Bearded sheep of West Africa.
11. Morocco sheep (*Ovis aries numidæ*).

IV. *America.*

1. West Indian sheep found in Jamaica.
2. Brazilian sheep.

Effects of Food on Wool.—The feeding of the sheep, says a French writer, has a most marked influence on the quality and quantity of the wool.

In this connection the rules to be observed are:—(1) To obtain wool of good quality and proper quantity the sheep should be well fed. The increase of the wool in length and resistance comes to a stop if the animal be deprived of the amount of food necessary for it. Well-fed sheep pay for the increased expense by the weight of the fleece and the better quality of the wool.

There is, however, an essential difference to be noted in long-woolled sheep. Too much and too rich food soon make the wool of short-woolled sheep too long, an inconvenience which has not to be feared in long-wool varieties.

(2) When the sheep receives too little food, or when the food given in sufficient quantities is not sufficiently nutritive, the wool preserves its fineness and acquires a certain length, but its resistance fails, as it is deprived of grease, which makes it harsh to the touch and as dry as flax.

(3) Regularity in the distribution of the food is of the highest importance, the wool soon showing the effects of this. This is what is seen when in winter the sheep are well fed with hay, grain, beans, and oil-cake, and when these supplementary foods are too quickly taken away in the spring.

The wool undergoes a time of stoppage later, continuing to grow under more favourable circumstances. The woolly hair is less resistant, and in a part of its extent covers a dead spot, a real scar indicating the irregularity of growth.

(4) Opinions differ as to the action of different foods upon the wool. All, however, agree in attributing a marked effect to fertile pastures. The fleece is more abundant; the hair is longer and noticeable for its softness, whiteness, brightness, and strength. Sturm lays down the rule that all foods which promote perspiration produce a finer wool; that is, those which include the most nutritive matters in the smallest compass.

Two sheep of the same breed, covered with the same wool, but differently treated, one being fed for fattening and the other in the usual way, show quite a different variety of wool from the first shearing. In the first place it will be longer, coarser, and will have lost its elasticity. This is more noticeable in the second and third shearing. The other sheep will have preserved all the original qualities of its fleece. The difference being continued up to the third generation, the offspring could not be recognised as coming from the same stock.

How to Judge Wool.—Merino sheep are judged for their wool by their natural characteristics. An Australian expert says: "In judging sheep always look at the shoulders first. Always assuming that the wool to be inspected is really fine, we first examine the shoulders as a part where the finest wool is to be found.

"This we take as a standard and compare it with the wool from the ribs, the thigh, the rump and shoulder parts, and the nearer the wool from the various portions of the animal approaches the standard the better. First we scrutinise the fineness and if the result is satisfactory we pronounce the fleece in respect to fineness 'very even'; next we scrutinise the length of the staple, and if we find that the wool on the ribs, thigh, and back approximates reasonably in length to that of our standard we again declare the fleece as regards length of staple 'true and even.' We next satisfy ourselves as to the density of the fleece, and we do this by closing the hand upon a portion of the rump and loin wool, these points being usually the thinnest and the most faulty. If this again gives satisfaction we designate all the wool 'even to density.' Now, to summarise these separate examinations. If the fleece is of nearly equal length on shoulder, rib, and back, and density on shoulder and across the loins, we conclude that we have a perfect sheep for producing valuable wool."

Sorting of Wool.—This is the tearing off of each staple of wool separately by the hand. It is generally entrusted to an expert who understands the grading of wool staples.

(*A*) The finest and most even drawn staples are found on the shoulders and the sides of the fleece.

(*B*) A staple of fairly good quality resembling that from the shoulders is got from the lower part of the back.

(*C*) On the loin and the back of the sheep the staple is shorter and of a more tender nature.

(*D*) The upper parts of the legs give a wool of moderate length that is often suspended in loose open locks; it is this part that is useful to the "Bur" plant by brushing off the spinose fruit and so acting as a disperser of the seeds. The staple so charged with Bur fruit or leaves becomes the burry wool of commerce, and the presence of the burs reduces the price of such staples. The wool from Buenos Ayres is often charged with burs of the Medick.

(*E*) The upper part of the neck gives an irregular staple that is often infested by the spinose leaves of wild prairie plants and seeds.

(*F*) In the central part of the back the wool is similar to that of the loins of a delicate staple.

(*G*) The belly portion includes the wool from the fore and hind legs. The staple is deficient in quality and of a tender nature.

(*H*) The tail of the sheep has a coarse, short, and glossy staple, often intermixed with kemps.

(*I*) The woolly fibres from the head, chest, and shins is of a stiffish and straight nature. The fibres from the shins are often termed "the shanks."

Grading of Staples.—The discrimination of the staple from a fleece gives rise to a great many names.

The finest, most elastic, and strongest staple is described as the:—

1. Picklock.
2. Prime.
3. Choice.
4. Super.
5. Head.
6. Downrights.
7. Seconds.
8. Abb.
9. Breech.

In worsteds the grades of wool are given as follows:—

1. Blue.
2. Fine.
3. Neat.
4. Brown Drawing.
5. Breech.
6. Cow Tail.
7. Brokes.

Superfine, middling, and common are applied according as the quality of the staple is determined in Botany wools, and this grading is dependent on adaptability to spin certain counts of yarn either up or down.

Wool Sorters' Disease (*Anthrax*) is caused by *Bacillus Anthracis*, which may enter the system either by the skin or by the internal organs. In the former case it gives rise to pustules, which become painful and cause perspiration, fever, delirium, and other disorders. In the latter case it produces the most serious ailments, such as blood-poisoning and inflammation of the lungs, which often prove speedily fatal.

With a view to the protection of the workpeople from attacks of Anthrax, the following rules have been recently issued to woolcombers by the Secretary of State:—

"For the purpose of Rules 1, 2 and 17 'opening' of any wool or hair means the opening of the fleece, or, if it be not in the fleece, the opening out for looking over or classing or other purposes.

"Duties of Employers.

"1. No alpaca, Pelitan, Cashmere, Persian, or camel hair shall be opened except
"(*a*) after steeping in water, or
"(*b*) at the washbowl, or
"(*c*) over an efficient opening board.

"For the purpose of this rule no opening board shall be considered efficient unless. . . . (definition to be settled after conference between Her Majesty's Factory Inspectors, the Bradford Chamber of Commerce, and the Trades and Labour Council).

"2. All badly-damaged wool or hair, fallen fleeces, and skin, wool or hair of all kinds named in Rule 1 shall be opened by an experienced man in the manner prescribed in Rule 1, and damped with a disinfectant, and then washed without being willowed.

"3. Every bale of Van mohair shall be steeped in water before being opened.

"4. No alpaca, Pelitan, Cashmere, Persian, camel hair or mohair shall be willowed except in a separate room provided with an efficient exhaust fan so arranged as to draw the dust away from the workmen and prevent it from entering the air of the room.

"No wool or hair shall be stored in a willeying-room.

"The floor of every such room shall be sprinkled daily with a disinfectant solution and swept immediately after sprinkling.

"The walls and ceilings of every such room shall be limewashed at least once a year and swept down at least once a month.

"5. The dust collected by the willows or other dust-extracting machines and from the opening boards shall be discharged into properly-constructed receptacles, and not into the open air. This dust shall be removed at least once a week.

"6. Suitable provision shall be made for keeping the clothing and food of all persons who are employed in the warehouse, or in any room in which is carried on willeying, or opening, or any other process through which the wool or hair passes before being washed.

"7. No person having any open cut or sore upon any part of the body shall be employed in a place specified in Rule 6.

"8. No person shall be allowed to prepare or partake of any food in a place specified in Rule 6 or in a carding-room.

"9. Sufficient and suitable washing convenience shall be provided for all persons employed in the places specified in Rule 6.

"The washing conveniences shall comprise soap, nail-brushes, and towels, and at least one washhand basin for every five persons employed as above, each basin being fitted with a waste-pipe and having a constant supply of water laid on.

"10. Requisites for treating scratches and slight wounds shall be kept on hand.

"Duties of Persons Employed.

"11. If, on opening a bale, any fallen fleeces or damaged material is discovered, the person opening the bale shall report the discovery immediately to the foreman.

"12. Any person employed in a place specified in Rule 6 and having an open cut or sore upon any part of the body shall immediately report the fact to the foreman.

"13. No clothing or food shall be kept in any place specified in Rule 6.

"14. No person shall prepare or partake of food in a place specified in Rule 6 or in a carding-room, or bring any food into such room.

"15. No person employed in any place specified in Rule 6 shall leave the works or partake of meals without previously washing his or her hands.

"16. If the fan or any other appliance necessary for the carrying out of these rules is out of order, any workman becoming aware of the defect shall immediately report the fact to the foreman.

"17. No alpaca, Pelitan, Cashmere, Persian, or camel hair shall be opened otherwise than as permitted by Rule 1.

"No badly-damaged wool or hair, fallen fleeces, or skins, wool or hair of the kinds named in Rule 1 shall be opened otherwise than as permitted by Rule 2.

"No bale of Van mohair shall be opened otherwise than as permitted by Rule 3.

"No alpaca, Pelitan, Cashmere, Persian, camel hair or mohair shall be willowed except as permitted by Rule 4.

"Factory Department, Home Office, February 1900."

Merino and Australian Wools.—These are from the Merino breed of sheep, which was first introduced into Sydney, and improved under the influence of the splendid climate and pastures of Victoria, Queensland, New Zealand, and Tasmania.

The merino wool is exceedingly soft and full in staple, and of a good colour. Port Phillip, Sydney, and Adelaide are the three principal kinds of staples that were introduced into the wool market from Australia.

These wools are used for either woollen or worsted goods, according to their character, quality, and length of staple. Mr. Charles Vickerman, in his work on *Woollen Spinning*, deals with colonial wools as follows:—

"There are many points about the manner in which colonial wool is sent to market and dealt with which give it an enormous advantage over our own. The flocks are often very large, and after being shorn, the wool is generally carefully and thoroughly skirted, *i.e.*, the short wool growing round the neck and legs and down the belly of the animal is taken off and packed into separate bales.

"The wool is also classed into different descriptions, merino and cross-bred not being mixed in the same bales, except in some of the smaller flocks. The consequence is that on its arrival in London large quantities can be taken direct to the comber without any sorting whatever, and the same thing is often done in the fancy woollen trade. A spinner or manufacturer can go round the warehouses and select the exact sort he wants; and sometimes during one evening he can buy his lots and have done with this branch of his business for some time. As the London wool sales generally last from three to six weeks, and as there are seldom less than 10,000 bales offered every night, there is plenty of choice. When this style of business is compared with the dilatory and unbusiness-like manner of buying English wool from the farmer, it will be seen what an immense saving of time and trouble there is to the user of colonial wool as compared with the user of English. A manufacturer can, and often does, purchase as much wool in London in a single night as would take him a month to buy in Lincolnshire or Shropshire. Very few people, except those having actual experience, have any idea of the vast variety of wool which is to be bought at the London sales. Almost every English sort can be matched there, and where the object to be aimed at is fineness of texture and softness of handle, the London colonial sale is the market to go to; there the finest grown colonial merinoes are to be met with. At least 75 per cent. of all the merino wool produced is used in the woollen manufacture.

"In conclusion, it may be remarked in the interests of the wool industries that it is very desirable that more of the wool should reach this country in the grease; that there should be less scouring of wool in the colonies and elsewhere; that the user of the wool, the manufacturer, should be the only party to scour the wool; and that every due regard should always be paid to retaining the natural properties of softness, strength, and lustre by avoiding all use of strong fixed alkalies in scouring and high heat in the drying." The remarks of Mr. Vickerman on the colonial wool trade are of as much importance to-day as they were when first penned.

There is still abundant scope for energy in developing the vast, unexploited wool resources of the world.

Welsh Wool.—This is obtained from two Welsh varieties of sheep, known as the mountain and the soft-woolled sheep. Some of the grasses of the mountainous districts are very nutritious, and it is probable that these sheep feed largely on the well-known sheep's Fescue grass (*Festuca ovina.*)

The wool from the mountain breed is of a coarser nature than that from the lowlands. The fibres from the soft-woolled sheep are chiefly used in the manufacture of the celebrated Welsh flannel.

"**Wethers**" indicates that the wool from a particular sheep is of the second year's clipping. The fibres are of a coarser nature than that of Hog's wool, and such staples are used for a more medium class or counts of yarn, or a coarser kind of woollen material. Wethers are generally good one or two-year-old fleeces. "Yearlings" is another term used for this class of wool.

Burs and **Burry Wool.**—"Burs" is a general term given to the fruits of certain plants of the Natural Orders Compositæ and Leguminosæ. The plants which produce the burs are not confined to one genus, but include plants of at least two genera. The first is known as *Xanthium* (Compositæ), of which there are two distinct species, viz., *spinosum* and *strumaria*, or the bur weeds.

The other genus of plants is styled *Medicago* (Leguminosæ), the principal species of which are *maxima*, *denticulatum*, *minimum*, and *maculatum*. These bur weeds have spiral or conical seed-pods covered with densely-set horny spines, which readily hook into the woolly covering on the sheep's back.

Fig. 119 shows a branch of the bur weed *Xanthium spinosum* with the leaves attached to the parent plant.

The leaves are broad, without spines, and the fruits are gathered into ovate heads, which are crowded with hooked spines. These readily adhere to the wool of sheep. The photograph is taken from a plant growing in the herbaceous department of the Royal Gardens, Kew.

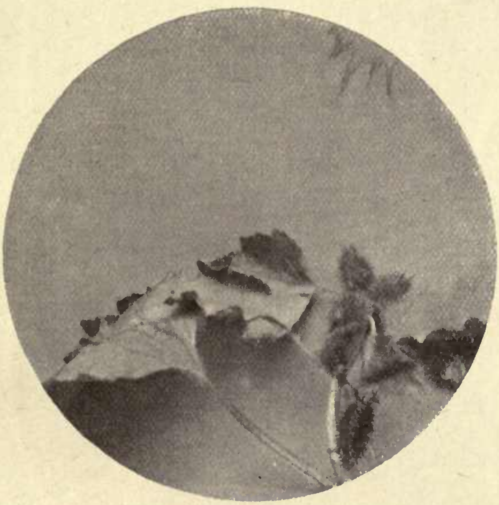

Fig. 119.—Bur weed.

The wool used by hatters is often infested by the spiny involucres of the bur weed, which are got rid of in carding.

Fig. 120 shows the spinose character of the spiral bur fruit of the Medicagos.

Fig. 121 shows the spines magnified under the microscope.

A bur cleaner has been devised by Garnett's of Cleckheaton, Yorkshire, and is much used in the woollen mills of Yorkshire.

Fig. 122 is an example of burry wool infested with various impurities, such as burs, spines, and other vegetable structures that are difficult to remove from the wool, except by a process of carbonising. A machine is often used, by which the burs are released, and cleaned wool passed on withour impairing the colour.

Shawl Wool.—This is the fine wool of Tibet. It is thus referred to by Sir J. D. Hooker in his *Himalayan Journals*:—"I went to see the shawl wool goats in a pen close by. There are two varieties: one is a large animal with great horns, called Rappoo; the other, smaller with slender horns, is Tsilloo. The latter yields the finest wool, but they are mixed for ordinary purposes. I was assured that the sheep (of which large flocks were grazing near) afford the finest wool of any. The animals were caught by the tail, their legs tied, the long winter's hair

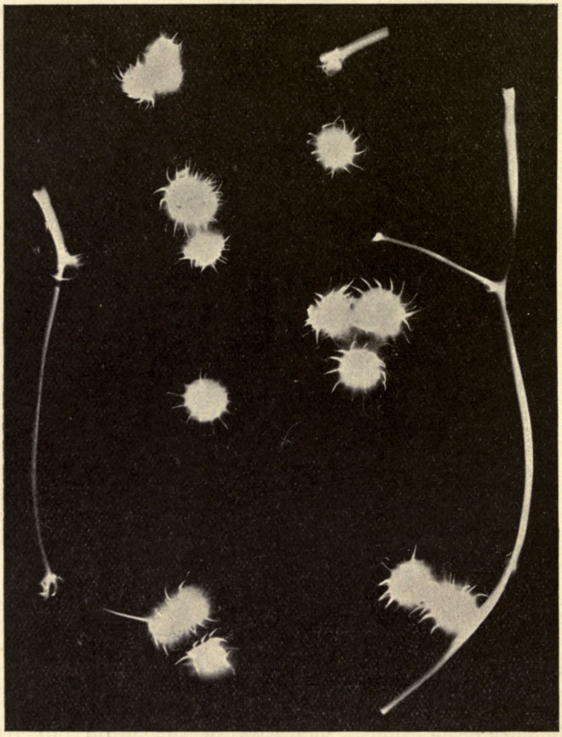

Fig. 120.—Spiny involucres of Medick.

pulled out, and the remainder cut away with a broad, flat knife, which was sharpened with a scythe stone. The operation was clumsily performed and the skin much cut."

Silesian Wool.—This, together with Saxony wool, constitutes the two principal classes of wool that are imported from Germany. The fibres are highly imbricated, possess great fineness of staple, are strong, and are elastic in felting properties. They are also well adapted for the spinning of high-class woollen fabrics where good felting and milling properties are essential. The felt cloths for piano hammers are often made from the yarns of these woollen fibres.

"**Hog's Wool.**"—This term is applied to wool fibres that are clipped from the lamb during its first shearing. These fibres are characterised by a curly appearance and pliable staple, and are adapted to spin a high class of counts. The basal parts of the fibres, at their insertion, have a tendency to cohere together and assume a tufty appearance.

Fig. 123 shows fibres of Hog's wool that have an excessive amount of flexuosity and curliness.

Irish Wool.—This is often a mixture of wool and hair of a coarse nature, depending very much upon the pasturage in which the sheep is

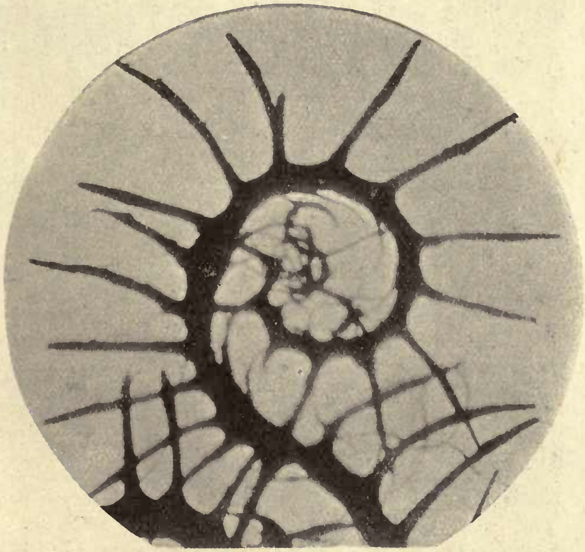

Fig. 121.—Spines of Medick (magn.).

grazed. The sheep which inhabit the plains of Ireland are larger in size than ordinary, and are noted for their unusually long-stapled wool, which has lately been much more used in quantity and improved in quality.

Northumberland Hog's Wool Fibres.—Fig. 124 shows fibres of Northumberland wool as it appears when taken from the sheep's back. The fibres do not show the imbrications very clearly owing to the presence of the yolk. Some are darker, and interrupted here and there by particles of impurities that have adhered between the natural yolk and the fibres of the sheep when living and browsing on the herbage. The imbricated scales are shown pretty clearly, but the fibres are not of one uniform thickness.

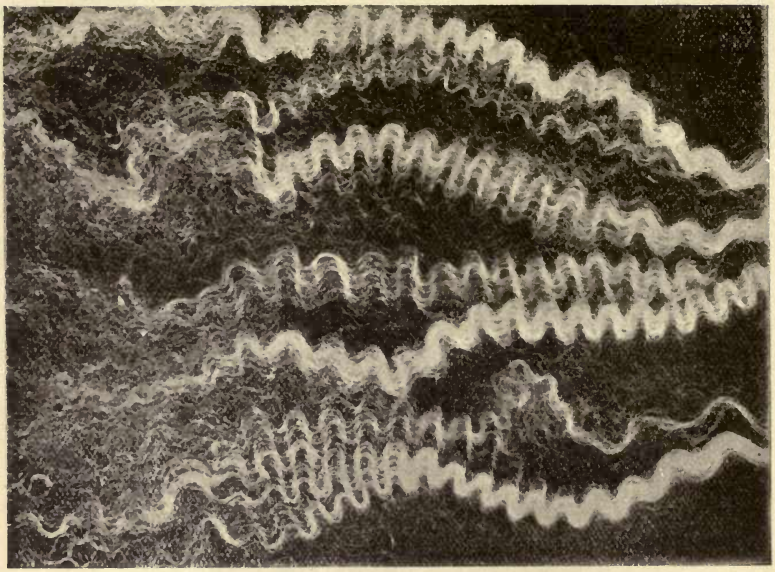

Fig. 123.—Hog's wool.

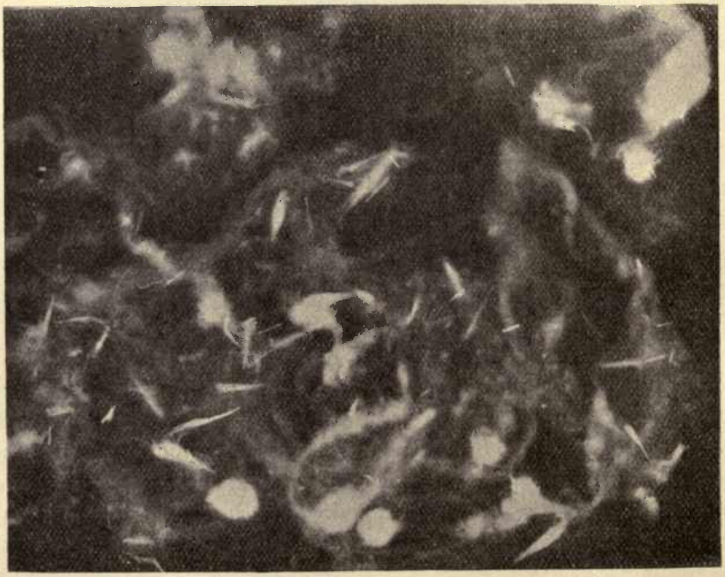

Fig. 122.—Burry wool.

Noils.—These are the short fibre combings of wool that are separated from the longer or worsted fibres of the combing machine. Fig. 125 is an example of noils from the merino wools. These are utilised in the process of the manufacture of felt hats.

The finest of the combings are chiefly from the Australian long and fine stapled wools. The Lincoln and Leicester type are hardly so good. The Mohair and Alpaca noils are chiefly the product of the two Auchenian goats. The most valuable noils are obtained from the rich stapled Botany wools. They are much used for the yarns in those districts where woollen shawl manufacture is carried on, particularly Delph,

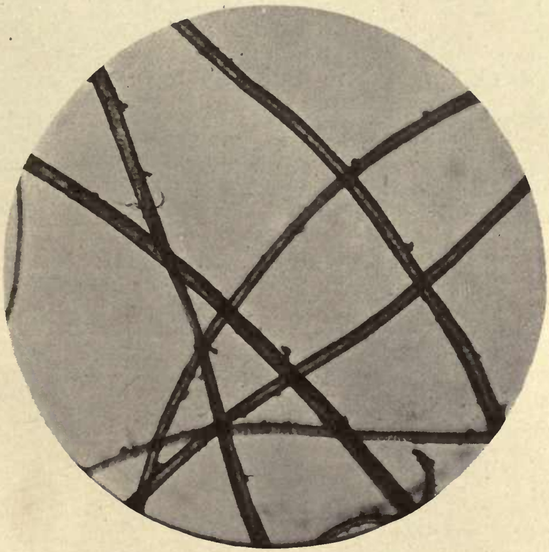

Fig. 124.—Northumberland wool.

in the Saddleworth district of the West Riding of Yorkshire. The noils obtained from the alpaca and mohair are much in demand for the manufacture of Scotch and of Kidderminster carpets.

Pelt of Wool.—Fig. 126 shows Lincolnshire locks taken from a newly killed sheep with the wool in its natural condition, attached to the skin. The curliness is characteristic of the woolly covering as it hangs on the sheep. The basal parts of the curly locks are clean and white, but the outer ends are charged with the yolk and the dirt that has gathered on the wool while the sheep has moved about in its natural habitat. The knottiness and tortuosities of the tips of the fibres are due to similar causes. The curliness seems to become lost

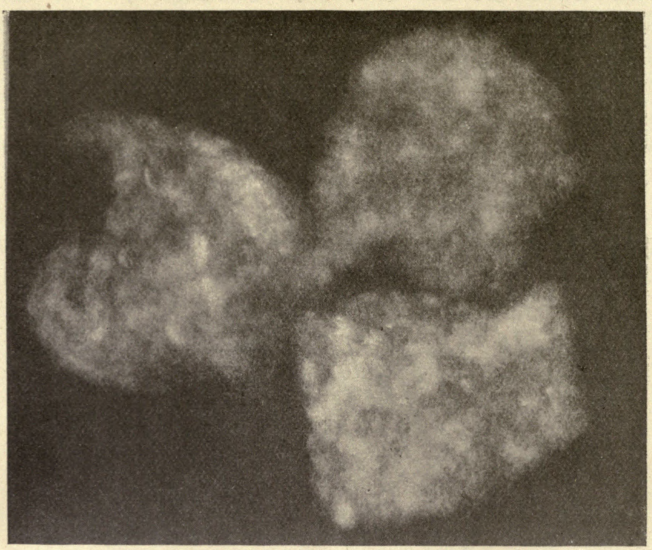

Fig. 125.—Noils from Merino wool.

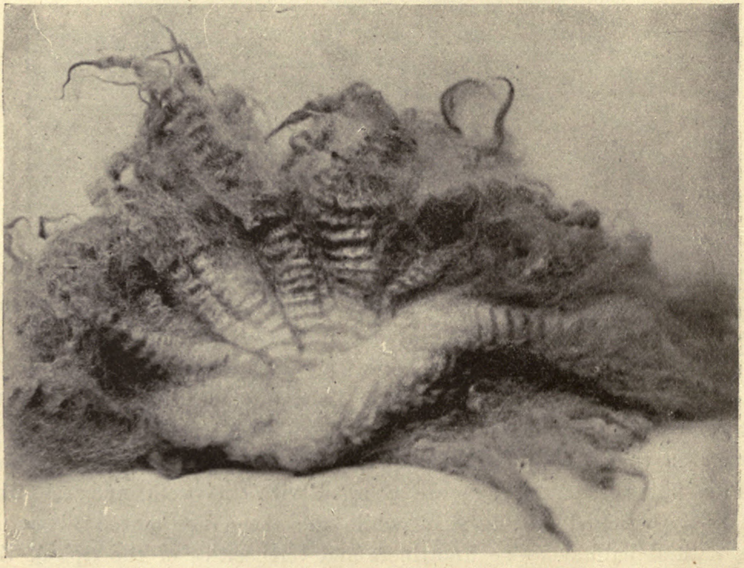

Fig. 126.—Lincolnshire locks.

at the tips of the woolly covering, but is recovered when the wool has undergone a scouring and cleaning.

Fig. 127 shows the fleshy side or carcase of the sheep with the wool attached. It is the reverse side of the one shown in fig. 147, with the dirt and impurities as before shown.

Fig. 128 is a part of the pelt after the wool has been scoured and cleaned. The curliness now seems farther apart from the membranous pelt than it was in the two previous specimens. In the latter case the undulations start from near the base of attachment, and gradually increase

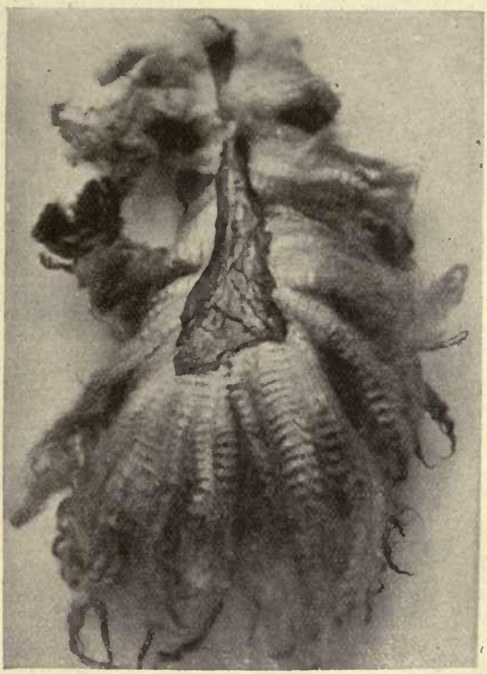

Fig. 127.—Lincolnshire locks as seen from the fleshy side.

as the tips of the fibres are reached. This character is readily seen on the sheep's back when the yolk permeates the woolly covering of the animal.

Imports of Wool.—The imports and quality of Australian vary with climatic changes. In the early part of December 1898, Messrs. Williams & Overbury reported as follows:—"Notwithstanding the strong statistical position of merino Australian wools, both active and prospective, the dulness of the woollen trade, coupled with the temporary weakness in the colonial markets which occurred during the latter part of October and the early part of November, gave rise to much uncertainty as to the probable course of prices at these sales. It is therefore satisfactory to have to record a firm market with a rising tendency in the case of merinos, and some recovery from the very low rates which have ruled for all but the finest cross-breds during the first week of the series." About the same time Messrs. Charles Balme & Co. wrote:—"The general characteristics of the new

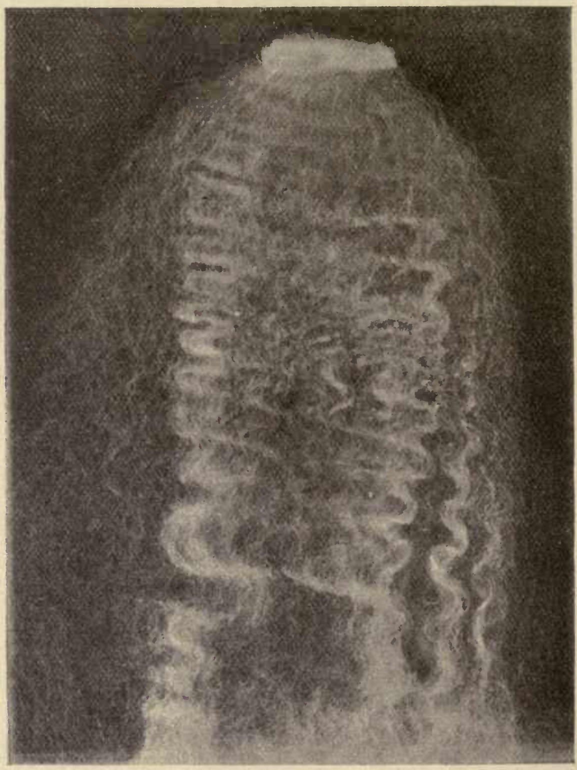

Fig. 128.—Pelt after scouring.

clip from New South Wales are very similar to those of the preceding season's growth. The wools strikingly illustrate the effects of successive droughts. The staple is lean and stunted, the hair is thin, and the fleeces carry rather more bur than was the case in the previous shear, and are deficient in yolk and frequently weighted with earth. Lightness in grease, however, is by no means an invariable attribute, as some clips carry both earth and yolk waste. The latter trait applies fairly generally to South Australian produce, although it is on the whole well grown.

Woollen Processes—*Greasy Wool.*—Fig. 129 is a small sample of raw merino wool just as it was received in its greasy condition at a woollen spinning factory in a country district of Yorkshire. Wool in

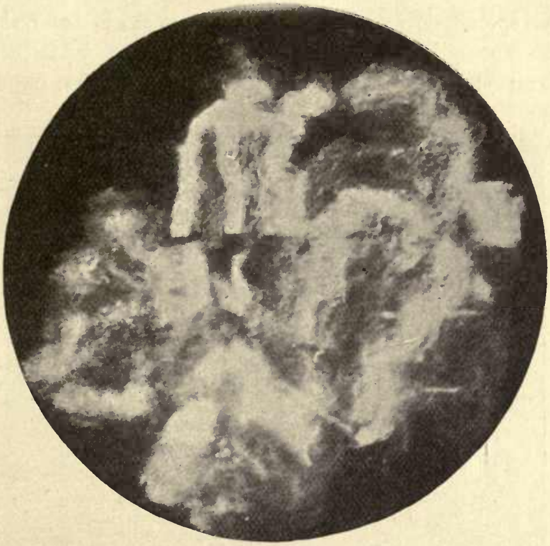

Fig. 129.—Raw merino wool.

the grease contains a great deal of yolk, which causes it to assume an oily or dirty yellow colour. Various kinds of impurities are met within it at this stage, and the wool retains its curly locks-like character.

The famous scientist Chevreul analysed the wool in its greasy or natural state, and gave the results as follows:—

Earthy substances, ...	26·06
Suint, or yolk, ...	32·74
Fatty matter, ...	8·57
Earthy matter fixed by grease, ...	1·40
Clean wool, ...	31·23
	100·00

Wool washing, when properly carried out, has the effect of making the staple pure, soft, and downy, while still retaining its elasticity and fineness.

Fig. 130 shows the same wool after it has been scoured and cleaned. In this state it is more harsh to the feel or touch, more rigid in its behaviour, and shows a much smaller amount of elasticity.

The *drying* of the wool is a preparatory stage to that of willowing. The cleaned wool as it comes from the drying, although pure and of a white colour, requires to be softened before it is fed to the carding engine.

Fig. 131 shows the wool after it has been willowed and oiled. In this state it is more cohesive and pliable in working, and the fibres are less likely to spread out, so that less waste is made from the material being spun. The oiling is intended to assist the wool in coming back to its natural state of waviness, but relieved of its impurities. It

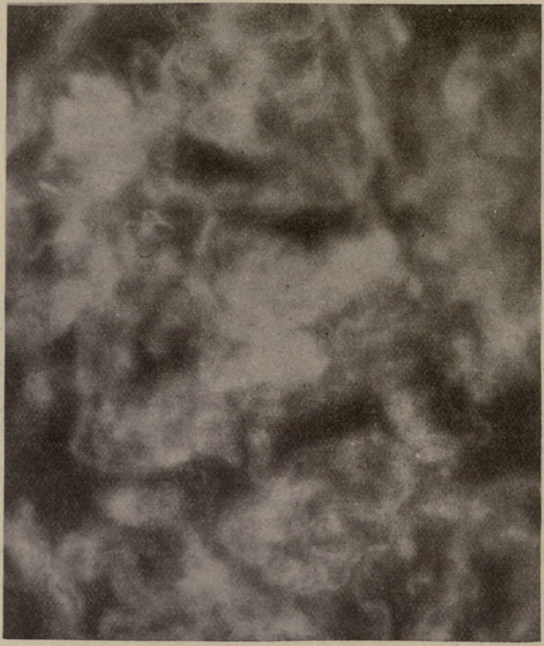

Fig. 130.—Merino wool after scouring and cleaning.

increases the power of the scales of the fibres to interlock and to cross felt together in a soft, round sliver.

Fig. 132 is a strand or one of the attenuated slivers from the condenser of the carding engine. The strand has now assumed a nearly uniform thickness, and the fibres are shown to have interlocked together crosswise. At this particular stage the fibres have little or no tendency to lie in contiguity one to another, and differ entirely in behaviour from those seen in a cotton roving, where the object is to get them to lie lengthwise, and to twist up spirally from the core of the yarn to the exterior surface of the screw line of twist which holds the roving of fibres together. In a cotton roving or a cotton yarn the more closely the fibres can cohere together and interlock spirally, the better and more compact is the yarn when spun. This cohesive tendency of the fibres of cotton to lie longitudinally is assisted by the twist put into the strand of rove or yarn. The strength is therefore increased and the length diminished according to the amount of twist that is put into the rove or yarn. Every interspace that might arise between individual fibres of cotton is taken up by the twist, which causes the yarn to become level, round, and elastic.

A Contrast.—The fibres of a woollen roving being differently constructed, they are not necessarily parallel; to make them so would

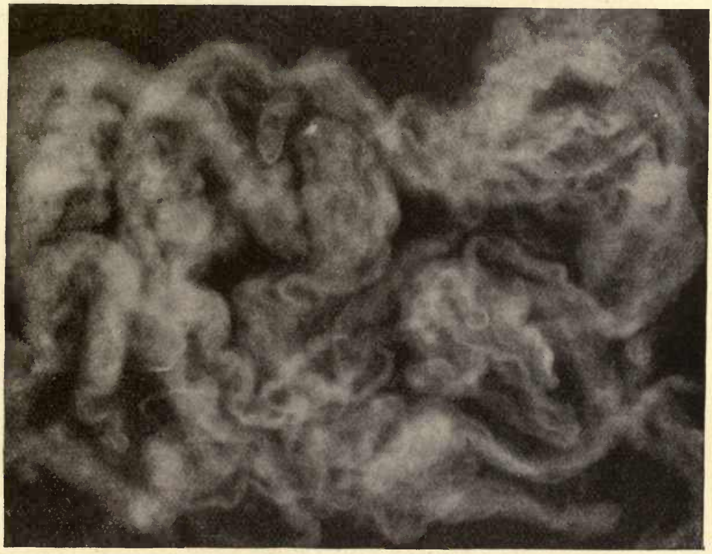

Fig. 131.—Merino wool after willowing and oiling.

deprive them of the lively undulations or spiral curls which most wool fibres assume when on the sheep's back. A woollen rove is remarkable for the crossing and interlocking of its fibres, and the numerous interspaces that occur between the interlocked fibres. It will be seen in the illustration that the fibres do not lie longitudinally together, but are distantly crossed, leaving an interspace, and are held together by the interlocking of the imbricated scales of the woollen fibres. The interspaces allow the air to enter, and thus assist the fibres in bending gracefully outwards and becoming wavy after the natural growth of the fibres during life. When the woollen fibres are spun into yarn the intercrossing and interspacing is not materially altered. The lucid surfaces of the fibres are then displayed, owing to the light having access to the finer openings and interspaces. If afterwards the yarns are dyed, the light can penetrate the openings and give effect to the luminosity of the fibrous yarns.

Fig. 133 is the yarn spun on the condenser mule still in the oil, as is indicated by its oily white colour and its lively curly character.

Fig. 134 shows the yarn when scoured and purified, giving it a clean and white appearance; but the elasticity of the curls is reduced by the action of the scouring and cleaning it has undergone. The yarn still possesses its softness and roundness.

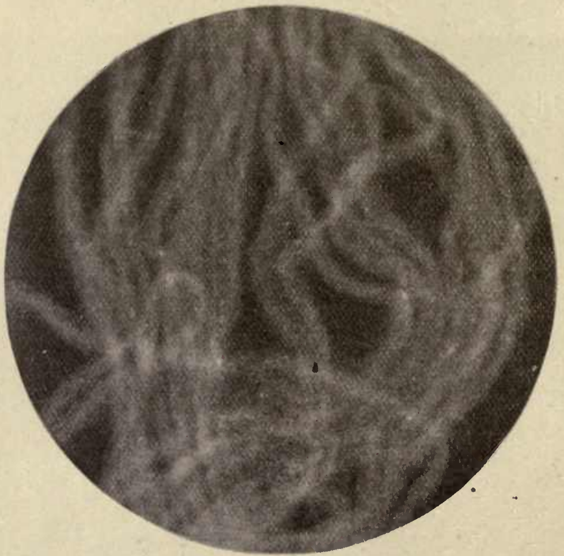

Fig. 132.—Sliver of wool.

Fig. 135 is an illustration of woollen yarn when magnified. It shows the fibres arranged spreadingly and oozy-like, with fine interspaces between the bulk of them.

Woollen fabrics are always in demand for articles of dress. A compact woollen cloth serves as baize curtains and pile woollen cloths are woven to imitate sealskin. The numerous intercrossings of fibres that compose a woollen cloth, and the felting character they assume, have the effect of repelling the rain, whereas a material made up of cotton is more readily absorbent. The hygroscopicity of the one is greater than that of the other.

Wool, Short.—The staple of this wool varies in length from 1 to 4 inches, and is used for hose or soft clothing fabrics.

Combing or long wool varies in length from 3 to 8 inches. "Whiteness of fleece is of less importance in the long combing, than in the clothing, wool, provided it be free from grey hairs. Sometimes, however, the fleece has a dingy brown colour, called a 'Winter stain,' which is a sure indication that the wool is not in a thoroughly sound state. Such fleeces are carefully thrown out by the wool sorter, being suitable only for goods that are to be dyed black. The fineness of heavy combing wool is not of so much consequence as its other qualities" (M'Culloch's *Dictionary of Commerce*).

Scouring Wool.—The foreign substances that are found in wool are generally incorporated with the yolk or *suint*, which is a compound of

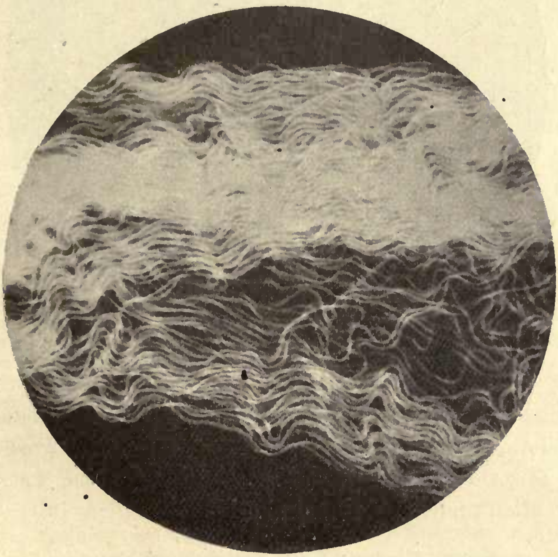

Fig. 133.—Oily spun wool.

potash and animal fat. Scouring is intended to remove the dirt, the burs, to some extent, and most of the extraneous matter that is met with in the raw wools. The removal of these impurities in the scouring ought to be done without damaging the surface or the physical structure of the wool fibre in any way whatever; and, after cleaning, the staple should behave in the spinning and the weaving process with a suppleness elasticity, and velutinous gloss that should be capable of improvement when acted on by the dyes used to bring out the attractive or sombre colours of woven woollen fabrics.

The temperature of the bath used in the washing of wool ought not to exceed 100° F. Neutral soaps and potash are preferable to soda. The fibres that are highly lustrous, such as alpaca and mohair, are more sensitive than those of other staples, and the exact temperature that will suit the washing of the fibres is best tested by experience.

The wools intended for worsted spinning are better with latent than strong felting properties.

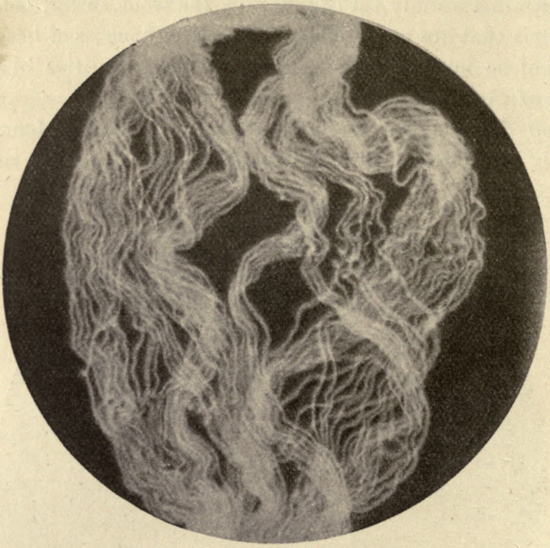

Fig. 134.—Woollen yarn scoured and purified (magn.).

In woollen spinning, generally, felting is a potent factor in most makes of cloth, where milling up is essential; but in worsteds, wools that have fewer felting scales, but otherwise of good, long, and fine staples, are often preferred on account of their excellent lustre.

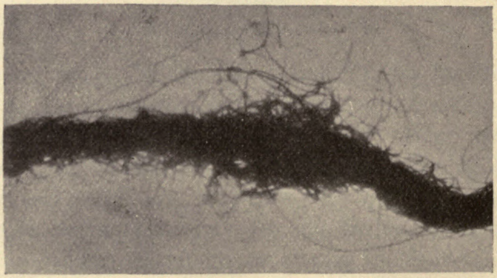

Fig. 135.—Woollen yarn (magn.).

When wool has been thoroughly washed it assists the operation of dyeing, and prevents certain faults appearing in the cloth when dyed, such as flecks or stripes. The appearance of the two latter is often to be accounted for by the wool having been only imperfectly washed or scoured.

Perhaps one of the oldest and well-known scouring agents is stale urine or "lant," which was formerly collected in the woollen districts. Owing to its value as a scouring agent it serves as a good wool cleanser, and renders the fibres soft and elastic, while their physical structure remains normal. The disagreeable odour of stale lant has caused other detergents to be used, such as ammonium carbonate, potash and soda soap.

The most suitable temperature for the scouring solution must depend upon the character of the various wools used, and the amount of dirt they contain. It is a good plan to test the temperature and the alkalinity of the bath by putting in a few samples, and then noting if the dirt or grease is persistent while immersed in the solution. If the bath is found suitable, a larger quantity may at once be submitted to the bath already formed.

Drying.—After the wool has been thoroughly washed, it requires to be dried as quickly as possible. A well-known process is to have the wool laid upon wire cages, and while in this position to pass hot air over it; this has the necessary drying effect upon the material. It is important that the drying should be done as evenly as possible; if done unevenly, it may cause the wool to become scorched. Another method of employing hot air is to use a machine in which the wool is fed and caused to travel over drying shelves or tables being afterwards delivered in a dry condition.

Wool Willowing.—This process has an effect upon the wool fibres similar to that which the opening machine has upon cotton fibres. In some cases it becomes necessary to mix wool and cotton together in the willow opener.

Fig. 136 shows wool and cotton fibres taken from the willow after having undergone treatment in the machine. The wool fibres show an entanglement and rolled-up character, while the cotton displays a want of curliness, but aggregates into tufts, showing a whiteness that is peculiar to these fibres. The willowing machine was formerly used extensively for the cleaning of cotton, but has latterly been discarded, and the separating and disentanglement of woollen fibres is spoken of as *Teazing.* The cylinder of the machine which effects this is run at 500 revolutions per minute, and the working rollers which take and separate the felted fibres from the cylinder are run at a slower rate. By this method the fibres are thoroughly separated, and rendered pliable and flexible for the process of scribbling. "Willowing" is synonymous with "Teazing."

Wool Carding.—The object to be attained in wool carding differs from that of cotton carding. In the latter process the cotton, as it passes through the card, has its fibres laid straight or parallel in relation one to another. In woollen carding the object is to open the fibres so that they will present a loose and open condition, and cause them to have a kind of crossing and recrossing effect, which in some machines exceeds 50 or even 60 crossings of the fibres by the time that the carded wool is doffed or divided by the patent Bolette condensers.

Oils for Wool Spinning.—These are used as lubricants in order to make the wool fibres more slicken in passing through the processes. It also prevents their breaking and becoming fluzzy or flying out of the machine as droppings. The general application of oil is to make up for the natural oil or yolk with which the fibres were charged in their natural

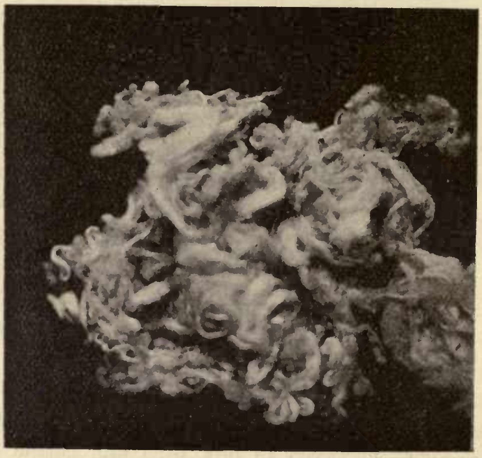

Fig. 136.—Wool and cotton mixed after willowing.

state. Several oils are used in this trade, such as neats foot oil, olive oil, and the oils obtained from tallow or animal fats. The supply of oil to the fibres ought to be very evenly spread.

Wool Extracting.—The removal of the burs and other spinose members of plants that are found in the wool staples is sometimes done by women, who are employed to pick out the burry and other foreign impurities.

The burring machine is sometimes avoided, and a chemical process is substituted, which is known as carbonising or extracting.

In process of extracting these vegetable impurities are destroyed by chemical agents. The wool is first steeped in dilute sulphuric acid, and then dried, so that the vegetable material may be thoroughly killed. The wool is afterwards steeped in a solution of soda, so that the acid may be neutralised, and it is then washed in the ordinary way. The carbonising of wool is often carried out by hat manufacturers, who find the burs in the wool difficult to deal with. When the vegetable burs and impurities have been carbonised in the stages of hat body-making, the carbonising serves a very useful purpose.

Carbonising is employed in the treatment of rags composed of mixed woollen materials, such as stuff goods with a cotton warp and woollen weft, or a mohair weft with cotton warp. Carbonising in this case destroys the vegetable fibres of the yarn, while the animal fibres are preserved and afterwards used in the manufacture of some other kinds of low-class goods. The fibres of wool that have been extracted from mixed goods are known in the trade as "Extract Wool."

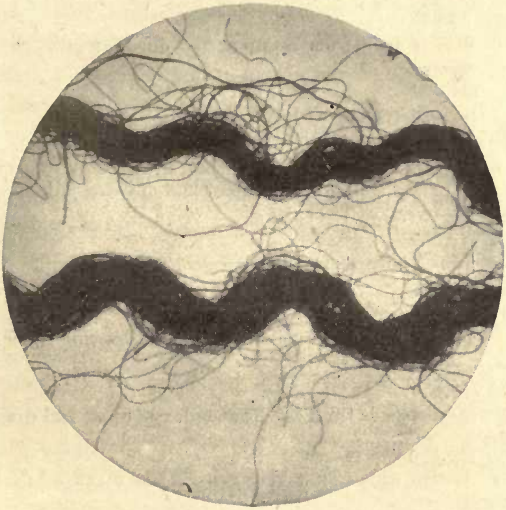

Fig. 137.—Worsted yarn (magn.).

Worsted Yarns.—Fig. 137 represents the warp and weft yarns of a worsted fabric. The principle of construction in these two yarns is nearly the same. They are built on the same principle as combed cotton yarns; the shorter fibres have been eliminated, and the longer woollen fibres lie in close contiguity together. The thinner yarn is the twist warp, and the thicker one is the soft covering weft in which the waviness is well marked, and contrasts with that of the lighter spun warp thread.

Worsteds.—In Bradford combed worsted yarns the drawing and redrawing of the threads is carried to a high pitch of perfection. As an instance of the care and attention bestowed upon it, a quotation may be made from Mr. Charles Vickerman's *Woollen Spinning* as follows:—"Take the following instance of the crossings and redrawings in combing and spinning a fine quality of 48s. worsted in the Bradford district:—

24	card slivers up at preparing gill.
8	from preparing gill up at backwash.
192	
3	from backwash up at gill for comb.
576	
4	slivers drawn off comb.
2,304	
20	comb slivers up at 1st finishing gill.
46,080	
4	balls from 1st up at 2nd finishing gill.
184,320	
6	tops up at 1st drawing gill.
1,105,920	
4	slivers from 1st up at 2nd drawing gill.
4,423,680	
4	slivers from 2nd up at 3rd (spindle) gill.
17,694,720	
4	ends from spindle gill at 1st drawing frame.
70,778,880	
4	ends from 1st drawing frame up at 2nd drawing frame.
283,115,520	
3	ends from 2nd drawing frame up at 3rd drawing frame.
849,346,560	
3	ends from 3rd drawing frame up at 4th drawing frame.
2,548,039,680	
2	ends from 4th drawing up at reducing frame.
5,096,079,360	
2	ends from reducing frame up at roving frame.
10,192,158,720	

"The roving is now ready for the finishing spinning, and is either taken to the worsted spinning mule, and gets as much further drawing as the condenser thread gets for its entire drawing. Need we be surprised that the worsted thread is a success in almost every fabric in which it is used; or that the woollen thread, as at present constructed is either an absolute or a comparative failure in every fabric in which it is used, and were it not for fancy cloths we should speedily come to an absolute deadlock."

Mungo is made up of felted pieces of cloths, clippings of coats, trousers, and disused hat brims, the fibres of which have been mixed with other felting wools and made into a cloth. When mungo is made up of pieces of cloth from good felting wools such as those known as "Port Phillip," there is more staple in the fibres though they are short, and a much better material is obtained.

Batley and Dewsbury have become the chief seats of the waste woollen trade, and a large business is done in utilising the shortest of fibres for the cheaper classes of goods.

Shoddy.—This is the product of the short fibres obtained from the rags of old stockings, woollen fabrics, flannels, stuffs, or any materials containing wool. These are known in the trade as "softs." Both shoddy and mungo yarns are used as a backing for some of the better woollen garments.

The history of the shoddy trade dates back to 1813, and the first districts to adopt it were Batley and Dewsbury in Yorkshire. Its most rapid and chief development was reached in the sixties about the time of the Lancashire cotton panic, during which many woollen waste spinners came from Yorkshire into Lancashire and offered woollen flocks in exchange for those of cotton. This was probably induced by the fact that Orleans cotton was selling at 2s. 6d. to 2s. 9d. per lb., owing to the American blockade of that time.

Aoudad (*Ammotragus tragelephas*).—This is a peculiar sheep-like animal, a native of the mountainous parts of North Africa, Abyssinia, and Barbary. Specimens of this animal are kept in the zoological collections at Belle Vue, Manchester, and other centres. The horns are spirally twisted and transversely indented. It has a peculiar goat-like appearance, and a long flowing mane of hairs which hangs down the front of the neck and legs.

Argali or Ammon (*Ovis ammon*).—This is the Argali or wild sheep of Central Asia and America. It inhabits the mountainous districts in summer and the valleys in winter. As a fur or wool-bearing animal, Professor Low says: "It has a fur of short hair, covering a coat of soft white wool. The colour of the fur externally is brown, becoming brownish-grey in winter. There is a buff-coloured streak along the back, and a large spot of a lighter buff colour on the haunch, surrounding and including the tail."

Alpaca (*Auchenia alpaca*).—The downy undercovering of the Cashmere goat furnishes the hairs or fibres that are used for the spinning of the yarn that is woven into alpaca cloth.

The alpaca sheep or goat belongs to the Llama tribe. The fibres are used in the same way as mohair for the spinning of weft yarns. These are intersected with strong twist yarns of about 2/80s. counts; the latter forms the warp, and is spun from Brown Egyptian cottons of good staple. The twofold yarn is chiefly spun in Lancashire, and is known in the trade generally as Bradford or ball warps. The warp yarn should be as level as possible, as any failure in the strength of the warp, or the presence of bearded motes, tends to deteriorate the character of the woven alpaca fabric.

Fig. 138 shows an alpaca woven fabric, the thick vertical twisted yarns with white tufts at the top are the twofold cotton warps, and the transversely arranged open fibres of yarns form the alpaca weft. The

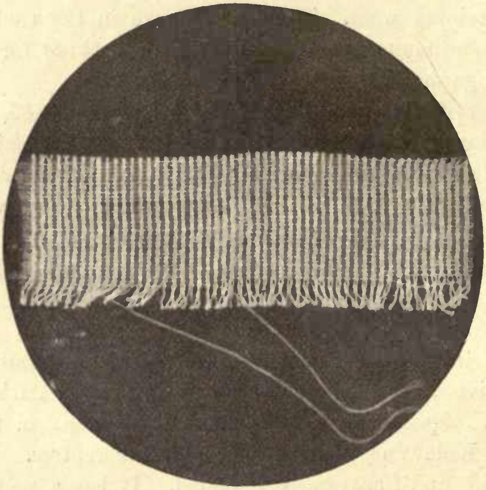

Fig. 138.—Alpaca fabric (magn.).

cloth is woven in the leno style, or the warp threads cross after each pick of weft. Such a cloth gains an additional strength owing to the extra twisting of the twofold warp threads after each pick of the alpaca fibrous weft. The two loose threads standing out from the fabric across the photograph represent the alpaca weft.

The alpaca cloth will be long and honourably associated with the memory of the late Sir Titus Salt and family. The village of Saltaire, situated in a lovely district between Bradford and Keighley, in Yorkshire, was founded and developed by the Salt family. Sir Titus not only benefited the industrial population of the village that commemorates his name, but his successful treatment of the alpaca gave an impetus to a section of the Bradford trade in general.

"It was in a bitter wind-storm, on the desolate table-land of the Peruvian Andes," writes a traveller, "that I first saw a ludicrously ungainly beast pop up from behind a rock, as the stumbling feet of my mule sent some loose stones rolling noisily down a precipice. The brute surveyed me for an instant, then shook his hairy head, gave a loud snort, and vanished. The echoes of the lonely pass bore to my ears a singular noise, as if an army of barefooted men were flying down the mountain. I had started a herd of grazing alpacas, and their sentry had warned them of my approach. The noise was the beating of their huge, cartilage, padded feet on the rocky ground.

"The alpaca, which many people confuse with the Llama, possibly because it is very closely allied to it in form and characteristics, is the gold mine of the Indians of the Andes, especially those of Peru, Bolivia, and Chili. It is an extraordinary brute in more senses than one. Its appearance, with its full coat of wool, is supremely ridiculous. It is as large as a big sheep, with a neck like a small giraffe, a mere bundle of wool carried around on four legs terminating with feet resembling those of an ostrich. Its legs are powerful and inappropriately graceful in comparison with the body they support and the feet in which they terminate. If the alpaca is absurdly ugly with its hair on, it is a positive burlesque after it has been fully sheared. It is sheared like a sheep, only its head is left covered. It is sometimes sheared once a year, yielding a six to eight-inch fleece; but the more provident alpaca farmers shear only once in two years, when they get wool from 15 to 30 inches long. The wool is found ranging in colour from white, through grey, yellow, and brown to black. The animal looks black, however, as the fleece exudes an oil and mats with the dust of the mountain pastures in which it roams at large. The fleece is very fine in texture, metallic in lustre when clean, and the fibre is very strong."

The fibres of alpaca are about 6 inches in length.

The various colours of alpaca wool embrace such shades as black, white, grey, and brown. It is also remarkable for its brightness, lustre, extreme softness, and long length of staple.

Asiatic Wool.—This wool fibre has been brought into use for spinning yarns. They are adapted to be used in the weaving of Oriental carpets and rugs at Crefeld.

Glutton or **Wolverene** (*Gulo luscus*).—This animal is found chiefly in the northern parts of the American continent. The fur is fine, of a chesnut colour. The animal has a dark mark on its back. The fur is in demand for muffs, cloak linings, and sleigh robes.

Llama Wool (*Auchenia llama*).—Llama wool fibres very closely resemble those of the alpaca, but are longer in staple. The animal has been considered by naturalists as a distinct species from the alpaca; yet some are of opinion that the alpaca is perhaps only a variety of the llama sheep. If this view is a correct one, it implies that all alpaca fibres ought to have received the name Llama fibres, but the name of alpaca would die hard nevertheless.

Mohair Fibres.—These are obtained from the hairy covering of the Angora goat (*Capra hircus*, Linn.), a native of the interior of Asia Minor. This hairy covering starts just behind the ears of the Angora goat, forming a kind of main, which is continued down the back and hangs down on each side of the animal in numerous curls of silky pliant fibres.

In the Bradford trade the yarn spun from mohair fibres has been

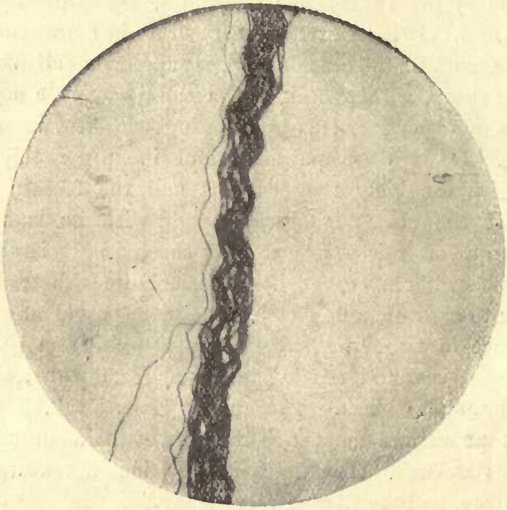

Fig. 139.—Mohair yarn fibres (magn.).

used as weft, in combination with 2/80s. twist from Brown Egyptian cotton, in the production of fancy lustrous dresses, and in the production of Utrecht velvet, etc.

The characteristic features of mohair fibres are their length, fineness, cohesiveness, soft and silky lustre. The fibres are the woolly covering of the Angora goat.

The soft and pliable character of the mohair yarn fibres is well shown under a 3-inch objective in fig. 139. In this specimen the warp threads are absent, but the sharp and nearly uniform undulations are the result of the leno character of the woven cloth, which is exactly similar to the structure of the alpaca, but with a greater amount of suppleness and lustre.

Fig. 140 shows a specimen of mohair fabric used for the dress goods; it has a rich lustre. The projecting ends of the fabric are 2/80s. cotton warp, and the weft face and figuring is of mohair fibre structure. Mohair fibres are also used in the manufacture of Astrachan cloth, which is noted for its curliness and tortuous ringlets. It has a milky or snowy white colour, and is well adapted for plushes or velvets, where the pilose surface forms the face effect of the woollen material.

For goods requiring a good lustre and silky appearance, for ladies' wear, the mohair fibres are especially well adapted.

Moufflon or **Musmon** (*Ovis musmon*).—This animal frequents the islands of the Greek Archipelago and the mountainous districts of Spain. In size it is smaller than the Argali. The horns of the male are involute, and contrast with those of the male Argali, which are revolute. The hairy fur covering is brownish with an undercovering

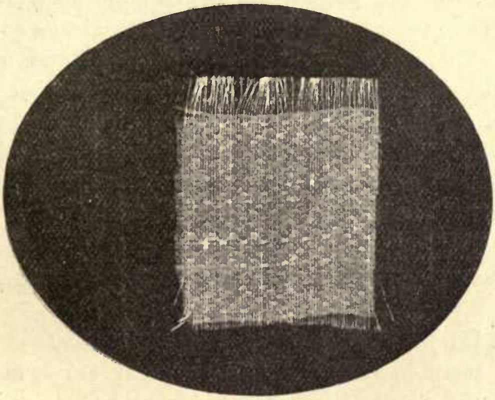

Fig. 140.—Mohair fabric.

of finer greyish-coloured wool. This animal is considered by some authorities to be the original type of our many varieties of domesticated sheep.

Yak (*Bos grunniens*, Linn.)—A quadruped which bears some general resemblance to the Bison. It inhabits the most inaccessible parts of the Himalaya Mountains.

On the upper parts of the body and sides is developed a thick, soft, woolly hair, short on the sides and forming a large tuft on the back.

The tail is clothed with a thick mass of pendent hairs, and from the body hangs a thick growth of hair which almost touches the ground as the animal sweeps forward. Sir J. D. Hooker mentions that the hair is spun into ropes and woven into a covering for tents.

The tails of domesticated yaks are used as ornaments by the Tartarians.

HAT AND FUR FELTING FIBRES.

Introduction.—The animal textile fibres used in the processes of Hat manufacture include those of wool, fur, and silk.

The microscopical structure of each group of the above fibres has a typical character by which they can be distinguished one from another.

The wool and fur fibres are essential in the making of felt and fur hat bodies and brims, but these are often charged with foreign substances, which occur mainly in the wool. These foreign bodies are the leafy spines and burs of *Xanthium spinosum*, one of the *Compositæ*, and the hooked or uncinate spines on the spiral legumes of different species of *Medicago*, belonging to the Pea family or *Leguminosæ.*

Calico, felt, and silk plushes are used in the manufacture of silk or top-hats. The gossamer body of the latter requires a special mode of preparation. The making of a felt hat necessitates a good many processes, both wet and dry. The felting and cohesion of the wool and fur fibres also necessitate the use of soaps and oils, while shellac, resin, and gums are used as stiffening and milling agents, also borax and spirits of wine. The dyeing of the wool and fur fibres with fast colours necessitates the knowledge of a specialist.

Fur Fibres.—The several characteristics of fur fibres used in hat-making have been enumerated by Mr. J. Marshall of Hyde, Cheshire, as follows :—

"The best [fur] is that which is from the beaver, and the following come next in merit in the order in which they are here placed : the Turkish hare, the Saxony hare, the Musk rat, the English hare, and rabbits of various localities. But furs of widely different values are taken from different parts of the same skin. The furs just enumerated are chiefly used for the special purpose of plying the nap required by ladies' hats. They are also extensively employed for mixing with other furs of inferior quality. Rabbit's fur, as may well be supposed from its abundance, is the sheet anchor for the fur hat manufacturer. Rabbit skins are sorted into first, second, and third qualities, and the value of the different furs they yield is determined in the following manner, viz. :—

1st.	Quality from the backs of best selected skins.			
2nd.	,,	,,	,,	second.
3rd.	,,	,,	,,	third.
4th.	,,	,,	sides.	
5th.	,,	clippings from the sides.		
6th.	,,	,,	,,	tails.
7th.	,,	,,	,,	heads.

"These different qualities of fur are mixed in proportions, dependent upon the price of the finished article which is required, and may roughly be said to constitute the foundation of all fur hats which are made.

"The surface, in the case of a hat of apparently superior quality, is, as will be subsequently shown, manipulated by a process of some interest and importance, by means of which other furs are superadded."

Fur fibres used in hat-making are much shorter than those of wool, and the serrations or imbrications of the scales are more closely set and indented transversely.

Wool.—Merino or Australian wool is largely used by hatters for felting purposes in the manufacture of what are known as felt hats.

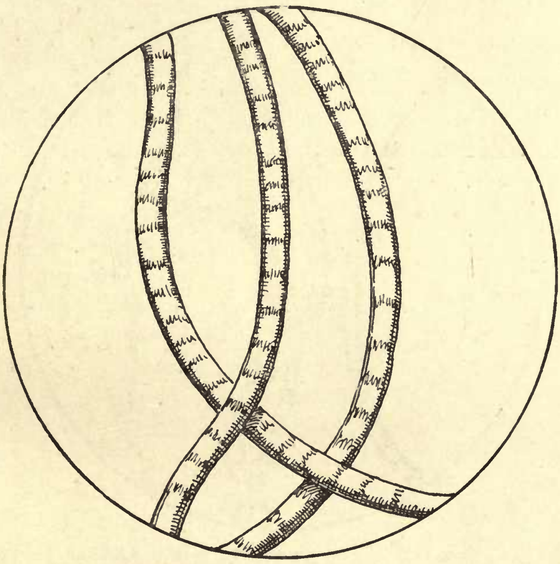

Fig. 141.—Merino wool fibre (magn.).

Fig. 141 shows the fibres of merino wool highly magnified under a ¼-inch objective. The fibres are cylinders with numerous overlapping or imbricated scales. If the fibres are mounted in hot water and then put on the field of the microscope, the scales will appear less imbricated than before; but where the fibres cross the scales they interlock with the open spaces on the other, as shown in the illustration, which is from a photograph of fibres immediately after removal from a hot soda solution. This may be regarded as one of the best principles in felting without the assistance of any adhesive substances, which become necessary when the fibres are manipulated for hat bodies, etc. Wool noils are also used in the making of felt hats.

The fibres of wool used for the making of felt hats are contaminated with burs and other plant impurities, which are removed chiefly in the first or opening process. The next process is the washing. The wool is immersed in a trough containing a scouring or soapy solution, to remove the yolk which adheres to its fibres, as shown in fig. 142. These are fibres of Heifer wool, as they appear under the microscope, with the yolk attached and in the natural state. In this condition the yolked fibres could not be used for hats; hence the necessity for washing the wool thoroughly.

The fibres, when cleaned, are carded and combed in a roller and clearer card, which straightens them. They are then combed off in a

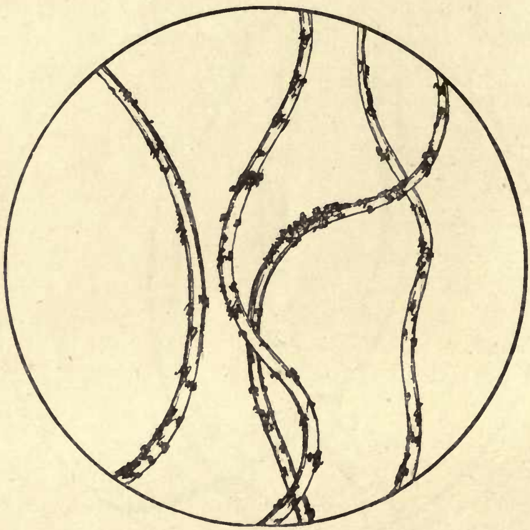

Fig. 142.—Wool fibres with yolk (magn.).

web and delivered in two separate slivers. These are guided on to conical blocks in a spiral curve, allowing a little for the brim or margin of the whole hat body.

In making a cone from the carded sliver web, it is necessary to cross and recross the lines, and to get the material as equal as possible in thickness in every part, in order to gain strength.

These cones of fibres are next put on a perforated iron plate, through which steam is blown and heat imparted. They are then hardened by putting them between folds of damp linen, and next taken to the plank or battery room. The other machines through which the material passes are the bumpers. These consolidate the felted material. It then undergoes twisting, stretching, proofing, steaming, stoving, and then, perhaps, a resteaming prior to being placed in the dye kettle. Other necessary processes it may be put through are blocking, or shaping, stoving, drying, and pressing with hydraulic pressure ; a further shaping if they are hard hats, and they are stiffened with a varnish of shellac, which assists the permanent stiffening of the hat crown. When the conical body is softened in boiling water it is forcibly drawn over a hat-shaped wooden block. A string is passed round where the band is to be, and the brim is then flattened out from the string. It must next be dyed in a bath of tinctorial solution, according to the colour that is desired. The colour imparted must be uniform. In dealing with the finer qualities of hats, each one may be separately dyed while on the block ; but with commoner qualities it is the practice to dye the material before the blocking is done.

The finishing process includes shaping on a block, over which crown and brim receive accurately their ultimate and permanent form, then pouncing, pumicing, or smoothing the whole surface with emery or glass-paper while the hat is still stretched upon the block.

The trimmer finally binds the outer brim with ribbon and inserts the silk lining, after which the brim may get more or less of a curl or turn-over, according to the prevailing fashion. The hat is then ready for the wearer.

The hat-maker requires to alter his styles frequently. In gentlemen's hats the height and the inclination of the crown of the hat call at times for very careful study, many questions arising as to the reception of a proposed new shape in society. The thickness and curling of the hat brim may influence the demand, while the weight of the hat may prove an obstacle to its success. The glossiness, smoothness, and uniform dye of the hat are matters of extreme delicacy.

In ladies' hats of fur or felt material, the whim of fashion necessitates a good deal of taste as to the shape of the hat, and particularly the broad or ladies' brim. These are heavily handicapped by the straw hat-maker, who is ever ready to formulate attractive or grotesque shapes according to the whim of fashion and of society. The changes of the styles or shapes often prove to be expensive items, particularly if a new style has only a very short run on the public taste ; but these are matters common to many other industries. Denton and Stockport may be cited as the chief centres for the hatting industry.

Stockport has a divided industry, viz., cotton spinning and hat-making. Silk hats are also made in Stockport. Denton is probably the largest hatting centre in the world. Hurst, a suburb of Ashton-under-Lyne, is not now, as it was once, a flourishing district for hatting. Failsworth, near Manchester, has for some years been steadily growing as a silk hat centre. The town of Bury is largely engaged in hatting, but, like Stockport, its industries are divided between that and paper and cotton manufacture. Romiley and Hyde, both in Cheshire, are engaged in hatting. Bury, Hyde, and Stockport are corporate towns; but Denton, Failsworth, Romiley, and Hurst are all governed under the management of Urban District Councils.

The subject of hat manufacture is taught at the Stockport Technical School, and students from Denton and other districts are permitted to attend the lectures in the practical department.

HAT MANUFACTURE.

THIS subject has for some years engaged the attention of the Examination Board of the City and Guilds of London Institute. The board have wisely appointed Mr. Walter M. Gardner and Mr. Benjamin Woodrow as examiners in this subject.

I am sorry to state that in May 1899 no examination was held in any hatting centre, owing to the fact that too limited a number of students intimated their willingness to sit for examination. This state of things is capable of some improvement, particularly in Bury and Stockport, which have finely equipped Technical Schools and energetic County Councils to encourage them in pushing forward their own industries. The study of the hat manufacture must necessitate some knowledge of silk, wool, and fur.

The silk is utilised in preparing the material for the "Gossamer body" of tall hats, and the getting up of the silk plush with a smart polish and finish of the whole hat structure. The wool fibres are still used for felt hat-making, either as noils or wool waste; or the wool (preferably Australian) is bought in the greasy state, and undergoes the several processes of washing, carding, blowing, settling, and planking; also pouncing, proofing, steaming, finishing, curling, shaping, and trimming.

The presence of foreign substances in the fur or wool, such as burs, seeds, and pitch, and the best methods by which they can be easily destroyed chemically without damaging the fur or felt material, has almost become a science. Of great importance, too, are methods of detecting impurities in the water used, and of determining relative hardness and softness of waters, and their influence upon the material intended for making into hats.

Beaver, The (*Castor fiber*, Linn.).—The fur fibres of the beaver are much in demand for use in the making of hats and other articles of wearing apparel.

These fibres, like those from most other mammals, are of two kinds: the outer pelage consists of long coarse fibres of a somewhat rigid nature, while the inner is formed of soft short down. The latter is so much in demand for fur or beaver hat-making, that some of the best stapled fibres have realised as much as ten shillings per ounce.

The fur fibres of the Rocky Mountain Beaver are very scarce. The general length of the down is one-quarter to half an inch.

Beaver fur fibres, when magnified, show two kinds of fur, the finer one being those of the inner, the coarser one those of the outer fur. The latter are distinguished by what may be termed deeply punched scales or transverse depressions, which nearly resemble those of the hare's fur, but are finer and more silky in the apparently moniliform markings.

Beaver fibres are superior to those of the hare and of the coney for beaver hat-making. Some fibres are used by tailors for dress materials, muffs, coats, etc.

Camel's Hair (*Camelus Bactrianus*).—Camel hair fibres are long, cylindrical, tapering, and finely serrated when seen under a moderately high-power of the microscope.

Camel's hair is much exported from Smyrna, Constantinople, Alexandria, and Persia. It is said to have been used in the making of hats, and for the manufacture of very fine pencil brushes, and in the woollen industry.

There are three principal types of camel's hair, known respectively as the black, red, and grey. The black is most in demand, and fetches the highest price; the red comes next; and the grey is of the least value.

The fibres of camel hair have been spun into yarns and manufactured into camel-hair blankets. Dr. Jaeger, whose name has long been connected with fabrics made of pure animal fibres for both sanitary and wearing purposes, has advocated the use of camel-hair blankets. It has been stated that these fibres are equal to the best of all animal fibres for protection and warmth to the skin. This may be true when they are compared with "woollen" fabrics that are partly made up of woollen and cotton yarns, and are spoken of and sold as "all wool" fabrics. The use of camel hair for the making of belts has received some attention from the manufacturers of belting fabrics for use in spinning mills.

Deer's Hair (*Cervus elaphus*).—The hair of the deer has been used for upholstery, stuffing for mattresses, pillows, cushions, quilts, quilted skirts, bustles, breast pads, and, on account of its lightness, for lifebuoys. Before using, it is recommended that it should be cleaned and dried in a hot chamber, in order to destroy any kind of germs or spores of fungi that may have been present in the fibres when in bulk.

Fig. 143 shows the hairs of the Red Deer (natural size). They are

Fig. 143.—Hair of Red Deer.

rotund and tapering, and end in the fine, needle-like, hard, but short, horny point.

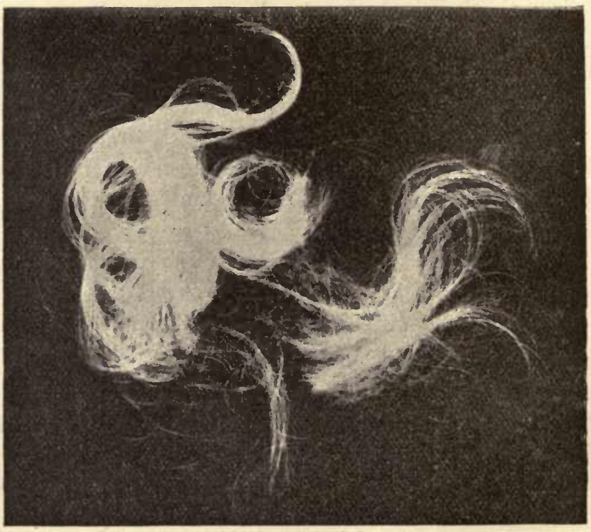

Fig. 144.—Dog's hair.

Hairs, Dog (*Canis*).—Fig. 144 shows the curly hair fibres or fur of the well-known retriever dog. When such hairs are cut from the animal, they still retain their peculiar curliness, as shown in the illustration.

When examined under a high-power of the microscope, these fibre hairs show a similar structure to those of hare fur. These fibres are certainly worth some further enquiry, as to whether they could not be used in the manufacture of felt hats, or for some similar purpose.

Hare (*Lepus timidus*).—The downy covering of the hare is much prized by hat manufacturers for its felting properties, and ranks as a good fur fibre.

Fig. 145 is a pelt or membrane from the belly part of the animal, showing the attachment of the fibres. The longest, which form the outer and attractive covering, are thicker than those underneath, but the latter possess superior felting properties.

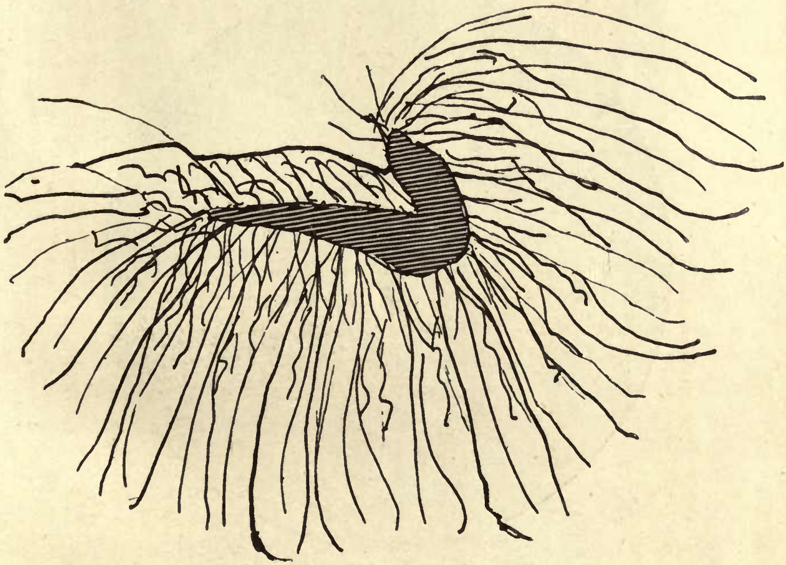

Fig. 145.—Pelt of Hare.

Fig. 146 shows a portion of the pelt magnified, with the fibres attached to the membrane.

When these "hare fur" fibres are examined under the microscope with a one-sixth objective they appear cylindrical, and have a thick, spiral, scale-like marking with transverse striations, upon which the felting property much depends. In a general way these fur fibres, when seen under the microscope, resemble a miniature Westinghouse brake. Both hare and rabbit felt with fur attached are used in glove-making for warmth during winter wear. They serve as a good edging for gloves and articles of wearing apparel for children, etc.

Jaguar.—These fibres are similar to those of the Buffalo, but are stiffer and not so definitely cylindrical. The fibre is sometimes split up curiously, apparently forming a thinner fibre in the middle of an entire one. This may be an isolated irregularity due to interrupted growth. The scarcity of this fur will, no doubt, prevent its use becoming general for any commercial purpose.

Musk Rat or **Musquash** (*Fiber Zibethicus*).—A native of Canada. The fur imported to this country is made into cheap hats for ladies.

Nutria or **Coypu Rat** (*Myopotamus Coypu*).—This animal is a native of South America. It bears some resemblance to the beaver, but has a round hairy tail. The skin is sometimes substituted for that

Fig. 146.—Pelt of Hare (magn.).

of the beaver. This skin is largely imported, and fur fibres from it have been used in felting, particularly for making the wideawake felt and billycock hats.

Rabbit (*Lepus cuniculus*).—The fur of the rabbit is largely used for the making of felt hats on account of its felting property.

Fig. 147 shows the hairs of the fur of the rabbit. The broad, thick, opaque fibre is of little or no use in felting, but is convenient for stuffing purposes, and is used by the upholsterer. The downy and finer fibres, which lie underneath the more solid ones, are singly marked with finer perforations. Fur fibres with a thick, dense wall, as in the illustration, are termed kemps. They have poor felting properties. The four thinner fibres are the downy ones with thin walls, but very deep transverse striations; these indicate good felting properties.

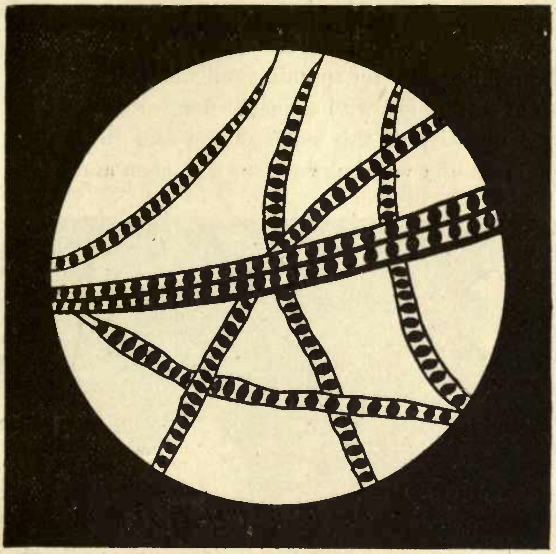

Fig. 147.—Rabbit fur (magn).

MINERAL FIBRE.

Asbestos Fibre.—Asbestos is the fibrous condition of certain incombustible minerals, chiefly found in the Takaka district of New

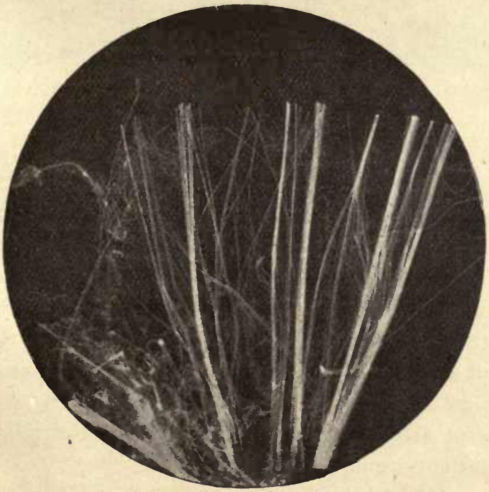

Fig. 148.—Asbestos fibres.

Zealand and in North America, and is perhaps the only native mineral product used for textile fabrics.

Fig. 148 shows tufts of these fibres from Italy, some of which are very fine and lustrous, resembling in appearance those of fine soft silk. They have been much used for spinning and weaving purposes on similar lines to those of cotton, but with a smaller number of processes.

Recently a quantity of this material was sent to London, and was placed in the hands of a well-known firm, who spun and wove the fibres

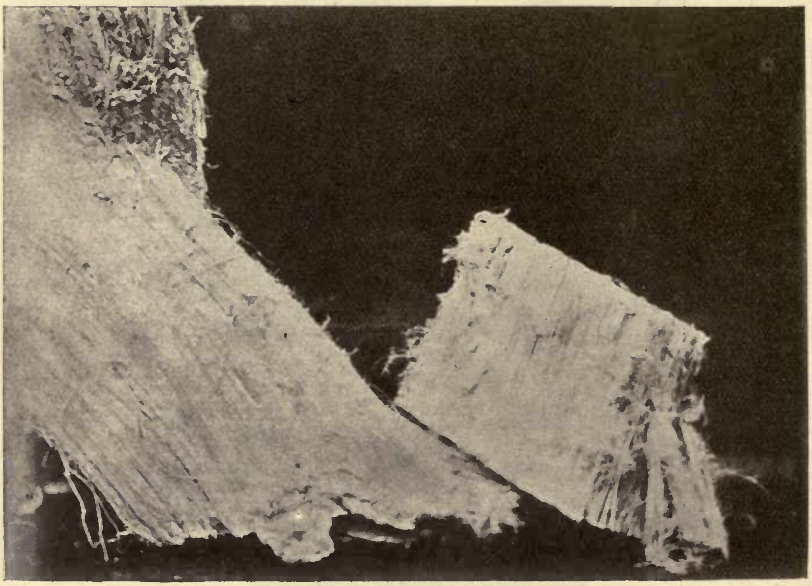

Fig. 149.—Asbestos (native).

into a cloth-like fabric, and pronounced its marketable value to be £20 per ton.

Asbestos has been used for protective coats of furnacemen and firemen's clothing; also for sheets, aprons, and gloves.

In theatres it has been found useful for drop-curtains for preventing the spread of fire. It is also employed for packing the pistons of steam engines and for steam boilers.

Two kinds of asbestos in their native state are shown on fig. 149; the one on the left is Canadian, and that to the right Italian.

For samples of asbestos I am indebted to the United Asbestos Co., Limited, of Manchester and London.

APPENDIX.

Pine-apple Fibre.—On December 20th, 1901, Messrs. Edward Barber & Son, colonial brokers, of 9 Mincing Lane, London, reported as follows:—"Only sample lots of pine-apple fibre have come on the market, and at present the stock is nil.

"At one time it was thought that it could be used for weaving with flax, but from a commercial point of view it would be more useful for making fine liveries."

Teazle (*Dipsacus fullonum*), Dipsaceæ.—Fuller's Teazle is a plant nearly allied to the thistle, with a glomerate arrangement of flowers that are invested with uncinate bracts.

The dried capitula of bracts are used by fullers for raising the nap of flannels, blankets, etc., without tearing the stuff material; machines are also used for raising the nap. Some species do not develop the hooked needle-like bracts, such as the Wood Teazle (*Dipsacus sylvestris*), and are therefore not used for nap raising in the woollen cloth industry.

Horse-hair.—This is extensively used in some descriptions of bristles for brushes. Horse tails and manes, the former being of greater value, are exported in great quantities from South America, Siberia, China, and Australia. Whilst a great quantity is collected in this country, South America supplies the finest quality. After the hair is cleaned it is drawn into various lengths and used for weaving hair-seating fabrics; the shorter lengths are used for brush-making, and the shortest is curled for stuffing furniture and mattresses.

Spongio-Piline.—A soft, wadding-like woollen material about one quarter inch in thickness.

The back of the material has a guttapercha coating of a flexible nature. This spongio material is much used in hospitals for poultices and hot fomentations. It has the property of retaining the heat without scalding. In the army hospitals at home and abroad it has proved of great service.

The woollen fibres are well fitted together in the wadding material.

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