The Rubber Tree Book

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BY

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PREFATORY

Go, littel booke, God send thee good passage,
And, specially, let this be thy prayere,
Unto them all that thee will read or hear,
Where thou art wrong, after their help to call
Thee to correct, in any part, or all.

CHAUCER.

INTRODUCTION

AT the opening of the Scientific Laboratory at Kew the late Lord Kelvin stated in his address that it was his firm conviction that the most important thing in science was exact measurement. This was just another way of stating that thorough efficiency was essential. There never was a time when there was a louder call for efficiency, and this was voiced by the present King—then Prince of Wales—when, after seeing what was going on all over the world, he addressed to our manufacturers and merchants the message—"Wake up, England!" Hitherto rubber-plantation companies, with any considerable area of rubber in bearing, have had such a glorious time of big dividends and easy circumstances all round, that there has been no urgent call for special efficiency in estate working. Times, however, are changing. It is being recognized more and more that efficiency is essential to success in all branches of industry and that the rubber-growing industry can be no exception to the rule.

While conscious of the very many shortcomings of this book, an endeavour is at least made to bring new light to bear upon rubber cultivation from various points of view which hitherto have received little or no attention.

The endeavour is also made to arouse the interest of the planter in the soil he cultivates and the trees he grows there by showing how varied and wonderful are the phenomena connected therewith. When interest is thus aroused, then work becomes congenial, habits of closer observation are stimulated, and the tendency is, therefore, towards increased efficiency.

In the factory, as in the field, improved methods are much required. The discrimination in price in favour of fine hard Para as against plantation rubber, amounting in the aggregate at present to over a million pounds sterling per annum, proves this beyond discussion. In the case of rubber, like all other products, quality tells and will always tell.

To assist in obtaining better results than have been secured in the past, to achieve these on more economical lines and with a greater regard than has hitherto been shown for the future welfare of the rubber-growing industry viewed as a permanent investment, is the object with which this book has been written.

The words, then, used by the famous old Roman historian, Pliny, in the preface to his *Natural History*, appear to be appropriate: "It is a difficult task to give newness to old things, authority to new things, Nature to all and all to Nature. To such, nevertheless, who cannot attain to all these, it is greatly commendable and magnificent to have attempted the same."

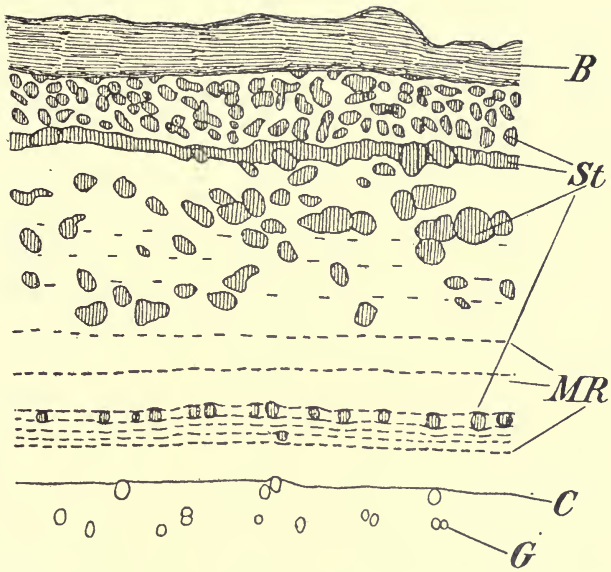

Diagram of Cross-section through Untapped Stem (Outer Part) of a Six-year-old Hevea. (Magnified 12 times.) B, Bark proper. St, Groups of hardened cells in cortex. MR, Layers of laticiferous vessels in cortex. C, Cambium. G, Some of water-conducting vessels in wood.

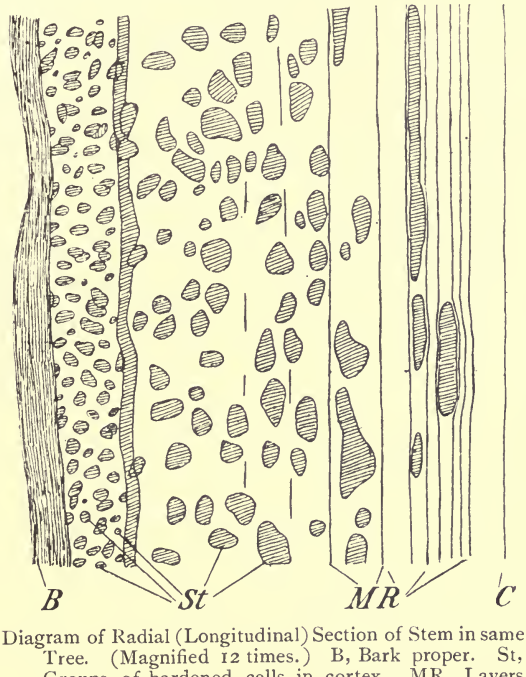

Diagram of Radial (Longitudinal) Section of Stem in same Tree. (Magnified 12 times.) B, Bark proper. St, Groups of hardened cells in cortex. MR, Layers of laticiferous vessels in cortex. C, Cambium.

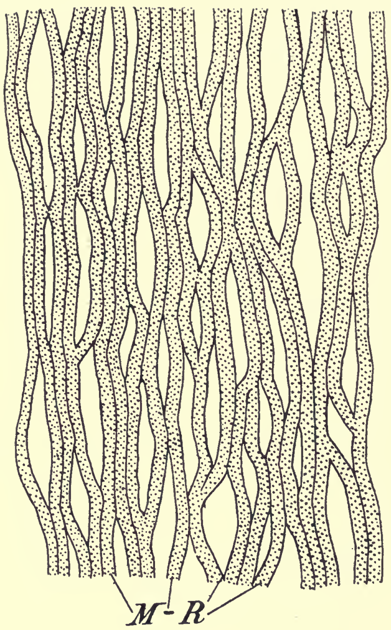

Diagram of Longitudinal Section parallel to Outer Surface across a Layer of Laticiferous Vessels. (Magnified 27 times.) This diagram shows the longitudinal courses of the vessels, but does not exhibit their numerous cross communications.

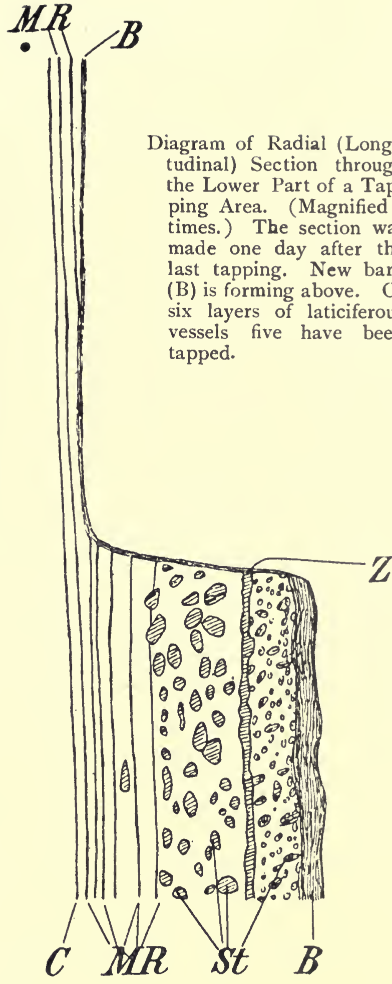

Diagram of Radial (Longitudinal) Section through the Lower Part of a Tapping Area. (Magnified 7 times.) The section was made one day after the last tapping. New bark (B) is forming above. Of six layers of laticiferous vessels five have been tapped.

B, Bark proper. St, Groups of hardened cells in cortex. MR, Layers of laticiferous vessels in cortex. C, Cambium. Z, The bottom of tapping groove.

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THE RUBBER TREE BOOK

CHAPTER I

WHAT A TREE IS

IT will be generally agreed that it is important that those who grow rubber should have some working knowledge of the nature and the structure of the tree they cultivate. It is not every planter who has had a university course, or who has even attended a course of lectures on botany. To most, scientific nomenclature has terrors of its own. A short, simple statement, in which there are no Latin words, and where Greek finds no place, may not be out of place.

The poet Wordsworth said of Peter Bell:—

" A primrose by the river's brim
A yellow primrose was to him
And it was nothing more."

That is true enough, but, as the late Professor Huxley once stated: " It would not have aroused Peter Bell from his apathy if he had been informed that a primrose is a dicotyledonous exogen with a monopetalous corolla and a central placentation."

For those desirous of having a working knowledge of the simpler facts of botany sufficient to enable them to conduct their estates intelligently, simple language is best. While it is true that a little knowledge may be a dangerous thing, it is not so dangerous as no knowledge, and, interest once aroused, the knowledge possessed can, and should, be added to. Though scientific terms may at first appear to be " fearful wild fowl," yet they soon lose their terrors to a persevering student.

To those who follow on, science soon assumes a warm, living aspect; as has been said, the dry facts form, like a skeleton, the mere framework which gives support to the entire, pulsating, life-retaining parts of the great organization.

Yet, while this is so, F. O. Bower, the Regius Professor of Botany in the University of Glasgow, is undoubtedly right when he says: "No subject has been more heavily weighted by technical terms and uncouth names than botany. The very pronunciation of them is often an offence to the ear of the cultivated classes, while to those who love Nature and natural things the language commonly used in botany is an effectual barrier to the pursuit of this spontaneous line of interest. As a matter of fact, the profession groans under the burden. It is largely a legacy of a misguided past, which can only be thrown off by a determined and collective effort. The result is that the vocabulary to be heard at any sitting of the Botanical Section of the British Association is certainly not such as is 'commonly understanded of the people.'"

Such a pronouncement justifies one who describes the anatomy of a vegetative organism in throwing aside all cumbrous terms.

The structure of a Hevea tree may be considered in four important divisions. These are: first, the roots; second, there is the stem; third, there are the leaves; and fourth, the means of reproduction, *i.e.*, flowers with the seeds.

The bodies of plants, like those of animals, are principally composed of innumerable very small cells, which together form a kind of honeycomb structure. These cells contain living matter called protoplasm. All plants, just like all animals, are living organisms, and are built up of living cells. A qualification to these statements is necessary in that rows of cells in the wood lose their cross-walls and their protoplasm and form long tubes that conduct water and salts from the roots upwards, while others in the bark form channels leading food manufactured in the leaves downwards.

What protoplasm (life-slime) just exactly is, no one knows. It is alive, and it acts with a certain intelligence, but how, or why, science can only very inadequately explain. The ancient Greeks had the idea that a spirit, a sort of wood-nymph, lived in every tree, lamented when it was injured, and died when it died. There is more than mere poetry in this idea. It has a very substantial basis of fact. The cells which, united together, form the structure called a tree, are alive, and the corporate life called a tree is also alive.

The cells themselves are very small, indeed, microscopic in size, and the nucleus—the brain and intelligence, so to speak, of the cell—is so exceedingly minute that it can only be observed in any detail when a very high microscopic power is employed. Yet these minute nuclei possess wonderful powers. Face to face with them, unable to account for their origin or their activity, or to give any reasonable explanation, science has to suspend payment. It is no explanation of protoplasm to state that there are in it proteins, fats, granules of starch, water and small quantities of certain mineral salts. In a living cell there is life and there is intelligence, two things a chemist cannot analyse.

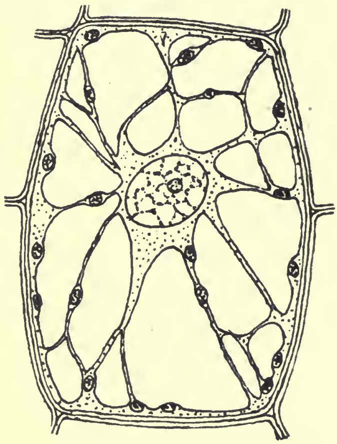

FIG. 1.—Illustration of a Cell in a Stem, highly magnified, showing Nucleus in centre, the Protoplasm containing Vacuoles (spaces) and Chloroplasts (the numerous dark bodies), the Cell-wall outside.

While it is true that a tree is produced from a germinated seed, yet it is only a half truth at most. Growth would not take place did not the living cells of the tree continually give birth to new cells. All plants and all animals resemble each other in this respect that—with the exception of the very lowest forms of life—they are built up of aggregates of cells. Growth in the case of both takes place only by the increase in size and subsequent subdivision of existing cells.

The world-celebrated scientist, Dr Alfred Russel Wallace, who announced his discovery of the law of natural selection simultaneously with Darwin, in an article upholding the spiritual nature of life, makes remarks of which the effect, with some modification, is as follows: Professor A. Weismann, perhaps the greatest of living biologists, describes the wonderful series of changes which occur in a plant-cell before its division. Till quite lately the nucleus, or small body in the centre of every living cell, was supposed at no time to have any special structure, as very little was visible by means of the very best microscopes. It has now been found by the use of certain stains that a most remarkable series of structural changes occur within it as a preliminary to division. A complex spiral structure first appears which arranges itself in loops. These divide transversely and split up longitudinally, each piece being connected by delicate fibres to special protoplasmic bodies at the top and bottom of the cell. An equal number of these pieces passes towards each of these bodies, and losing their separate identities, they run together to form nuclei at both ends of the cell. Division of the cell by means of a transverse membrane then occurs, the two resulting cells being apparently identical with the parent cell and with each other. But in the early stages of development each may possess distinct properties, since they may become the starting-points of different organs or structures of the body. This implies some selective and directing agency in order that the specially-modified cells may appear in the right place and at the right time.

Continuing his remarks, Dr Russel Wallace says: " The complex changes going on in every cell and atom of every living creature during its whole term of life are summarized in the one word ' growth,' and being so familiar, this term is taken to explain everything while it really explains nothing.

" Professor A. Kerner, in *The Natural History of Plants*, refers to the chemical explanation of the phenomena of cell-division given by the materialistic school of physiologists: ' It does not explain the purposeful sequence of different operations in the same protoplasm without any change in the external stimuli, the thorough use made of external advantages, the resistance to injurious influences, the avoidance or encompassing of obstacles, the punctuality with which all the functions are performed, the periodicity which occurs with the greatest regularity under constant conditions of environment, nor, above all, the fact that the power of discharging all the operations requisite for growth, nutrition, renovation and multiplication is liable to be lost.' "

The want of any reasonable explanation compelled even the out-and-out materialist Haeckel to admit that every cell must be possessed of a soul.

These cells are not only alive, but the intelligence behind their movements is extraordinary and incomprehensible. Some devote themselves to the formation of root-structure, and, according to their position in the roots, form themselves after various patterns, with thinner or thicker walls, and more or less elongated. Others devote themselves to the construction of a stem conceived on a wonderful plan, with a canal-system for conducting water, distributing agencies for food, and warehouses for storing up reserve supplies. Still other cells in the leaves carry on with success the most intricate chemical operations, using the actinic (chemical) rays of the sun for a motive power.

A tree is, then, a wonderful organism. Every cell citizen, so to speak, knows his duty and performs it without any police after him.

Long before humanity had ever dreamed of co-operative societies, the tree cells had solved the problem. Each for all, and all for each, was their rule of life worked out in perfect harmony.

CHAPTER II

THE SOIL

"BACK to the soil," is the cry of many weary with the harassing conditions of our present-day civilization. The soil is the source from which nearly all our food-supplies, directly or indirectly, are derived. To those who are engaged in its cultivation, information as to its origin and nature should be of special interest.

Scientists tell us that there was not always soil. In the early ages of our earth, when the molten materials had so far cooled down that a solid crust of igneous rock was formed, there was no soil spread over these rocks. When the temperature of the globe fell sufficiently low, the water-vapours began to pour down and fill the hollows, and the action of water and alternations of temperature dissolved and powdered portions of the crystalline rocks, producing the soil and releasing valuable mineral salts. In the course of ages the ever-active volcanic forces distributed dust everywhere, and in this way helped to form the soils, adding greatly to their fertility.

The soil so formed, however, was not soil as we understand the term. It was barren and dead. There were no bacteria in it, and, consequently, only the lowest forms of plant life could exist. The first forms of vegetation which appeared in the steaming swamps were of a very low order—algæ, lichens and mosses. From the decayed remains of these some vegetable humus was formed in the course of time. They were, in due course, succeeded by gigantic fern plants. It was not till much later that flowering plants and trees appeared. These could not appear until after the existence of bacteria to furnish supplies of nitrogen to their root-systems.

Darwin was much puzzled to account for the sudden appearance of these high forms of vegetation amongst fossil remains. On one occasion, writing to Dr Hooker, he described it as "an abominable mystery." It was, like what is called "the apparition of man on the earth," a mystery science has never been able properly to account for.

That soil was originally barren, and, under certain circumstances, is still barren, is not difficult to prove. G. F. Scott Elliot, in *Botany of To-day*, has the following:—

"We do not realize the immensity of the task that lay before the first vegetable cell. Here was the earth, utterly and entirely mineral, without the slightest taste or touch of organic matter, neither 'soil' in the gardener's sense nor bacteria; the water was without micro-organisms, and the land was original rock or barren sand, or bore mud.

"The author once had the opportunity of seeing on a large scale the extraordinary difference between good and what may be termed 'mineral' earth. In making a tunnel near Glasgow a layer of almost liquid clay had been struck. On a field close by the ordinary surface-soil had been removed from a few square yards and piled up in a long mound, and the whitish clay, which had been buried deep in the earth since some time in the ice-age, was deposited on the vacant space.

"After the work had been stopped there was an extraordinary difference between the flowers on the mound of surface-soil and those on the mineral clay. During the first two summers scarcely a plant succeeded in establishing itself on the clay, and those few that did manage to grow did so unhappily, and seemed to depend upon brown dust, or accidental patches of earth. On the mounds of surface-soil the weeds and grasses were extremely luxuriant."

Volcanic action, as has been said, has always played a very active part in the production of soil materials. The dust thrown into the atmosphere by the volcanic explosion of Kratakoa (an island lying off the south of Sumatra) coloured the sunsets of the world for nearly three years. The amount of dust thus created must have been immense. The more recent volcanic eruption of Mount Pelé, in the island of Martinique, in the West Indies, created so much dust as to interfere with the navigation of the Straits of Malacca.

Many such cases could be cited to account for the disintegration of ancient rocks and the deposit of soil did space permit. It will, however, be evident that immense quantities of dust are always being added to the surface of the soil. Even such comparatively modern buildings as those constructed in our own country by the Romans a few centuries ago have been buried under twenty or thirty feet of wind-swept dust and soil.

The effects of what is called " weathering " on the ancient rocks has for long centuries been adding, and is still constantly adding, to the soil. The changes of temperature between day and night, summer and winter, have all an influence in the disintegration of the rocks. This will be readily understood if one considers for a moment the composition of such a common rock as granite, for example. Granite is principally composed of felspar, quartz and mica, and under the influence of changes of temperature these do not expand and contract equally. As a result of this cracks and small fissures are constantly occurring and water gets in. Water is the great solvent of Nature and it immediately attacks any mineral salts present, honeycombs the rocks and sets free particles of mineral and salts to be added to the soil. Outside of the Tropics the water acts in a second way. Present in these cracks or fissures in time of frost, it becomes ice, and in expanding increases the size of the fracture. It is conceivable that soils now in tropical areas owe their existence in part to the disintegrating action of frost upon rocks during times when, owing to changes in the position of the earth's axis, areas that are now tropical were temperate or even colder, just as others now arctic, such as Greenland, were once temperate and even tropical. The weathering effects of oxygen, various acids and carbonic acid gas in the water (the acids formed largely by bacterial action) have also played an important part in adding to the soil. In rocks and stones there are many forms of mineral which, when moisture is present, readily combine with oxygen or carbonic acid gas and dissolve or break up. Iron, for example, is a very common mineral, and when moisture is present and oxygen attacks it, it oxidizes, turns into rust, and is easily powdered away. So with carbonic acid gas; when combined with water it dissolves many forms of mineral readily and renders them more available for the purposes of vegetation.

Although the variety of mineral substances which compose the crust of the earth is immense, some of them are present in but small quantities. Yet it would seem that some of the latter are very important to the plant. For all practical purposes, those which concern planters and agriculturists are but few: silica (sand) and silicates, sulphates and phosphates of alumina, iron, lime, magnesia, potash and soda in a compound form, together with carbonate of lime, the carbon of organic origin. Nitrates, except where they occur in extensive deposits, as in Chili, enter little into the composition of the crust, and in the soil are continuously being used up and replaced. From these elements trees and other plants derive the supplies of nitrogen, sulphur, phosphorus, potash, iron and other elements which they require in addition to the carbon obtained by the leaves from the carbonic acid gas of the atmosphere.

The layer of soil from which plants can obtain their supplies is very limited, being only a few feet, and sometimes, in extreme cases, even only a few inches in depth. It is composed of particles or grains of silica and the other minerals above noted, in all sorts of irregular shapes and sizes. Mixed up with them are decayed vegetable and animal remains. This mass of humus and soil represents a sort of capital fund, the savings, as it were, of past ages, which living trees and plants draw upon for what they require during their lives. When they die and decay their own dead bodies are added to replenish the stock.

As there can only be a limited amount of the necessary mineral salts in the small particles of the soil, the question may arise in some minds: How is it that during centuries past these stores have not been all rendered and used up? Certainly one does not lose sight of the fact that the fall of the leaves and the decayed bodies of the trees themselves, when they have died, have during those long periods re-enriched and ever added to the humus and salts of the soil. There are also the food supplies liberated by weathering of rocks. But yet this does not entirely explain matters. It is largely due rather, as already stated, to the fact that there is a constant showering down of fresh particles of dust on the surface of the soil. In this way fresh particles containing mineral salts are always being added to the surface-soil. The atmosphere is always full of such dust, the causes of which have been discussed. Were it not for the dust present in the atmosphere, instead of seeing blue skies overhead we should look up into a black and gloomy vault above.

A further point of the utmost importance in considering soils, yet generally neglected and, so far as the writer is aware, never referred to in any volume dealing with rubber cultivation, is the ability of soil to draw and raise up water from sub-soils and to attract it horizontally from surrounding regions. The importance of this may not be recognized at first glance, but it is vital. Did soils not possess such power to bring forward fresh supplies of moisture, plant-life might perish. When the roots of a tree are drawing in nourishment in a state of solution from the soil, it is evident that the root-cells are draining the soil in the immediate neighbourhood of all moisture. There is, therefore, a process of suction proceeding, and a movement of films of moisture towards the roots of the tree from all sides. Were it not for this, so soon as the supplies of water close to the roots were exhausted, the roots would have to immediately cease feeding; growth would not only be suspended, but the plant would not have material to draw upon to repair the waste constantly going on, and if fresh supplies of water were long delayed it would perish. It is as important to have a free circulation of water in the soil as it is to have air freely admitted.

This capillary power, as it is called, which the soil possesses of drawing up water from the sub-soil has the result that there is a constant movement of moisture towards the surface, where the water evaporates quickly under strong sunshine. This loss of moisture is far more serious than is recognized, and may have a distinctly retarding effect upon the growth of the trees. It has the effect of putting the trees upon a reduced diet, for as food can only be absorbed in a state of solution, when moisture is scarce food absorption is slow and growth expansion hindered. As elsewhere pointed out, a good rainfall means good growth and good yields of latex. But a good rainfall may be largely allowed to waste itself by means of rapid evaporation if not hindered. This is where cultivation plays so important a part. When the surface of the soil is loose and broken up by cultivation, the surface-soil loses this power of drawing up moisture from the sub-soil to the surface and the moisture is kept at a low level and rainfall is conserved. In this way—so to put it—a good manager can make up for a deficient rainfall and can do much to ensure good growth and healthy conditions for the trees on the estate which is under his charge.

There are, perhaps, four classes into which soil may be roughly divided. First, there are the light, sandy or gravelly soils; second, there are loam soils; third, clay soils; and fourth, humus soils, that is, soils largely composed of decaying vegetable matter.

Light, sandy or gravelly soils have sometimes a good stiff sub-soil, and thus trees are enabled to establish themselves and to resist the effects of drought. If, however, the light surface-soil is of considerable depth it will be exceedingly difficult to establish young trees, and the trees, even if established, will always suffer severely in times of drought. In such cases manuring with chemicals is of little service. The best plan to follow is to stiffen the soil with an abundance of green manure as frequently as possible till it assumes a good texture.

The term "loam" is one very often misapplied. Loam consists of a good mixture of sand and clay. It is a sort of intermediate soil, being neither sand nor clay, but a thorough intermixture of both. It is better than either for the purposes of most cultivations, including rubber, being neither too porous nor too tenacious of moisture.

By the term "humus soil" is meant a dark soil, largely composed of decayed matter of vegetable origin. Such soil is exceedingly fertile and full of bacterial activity.

While most soils are composed of particles varying largely in shape and size, in clayey soil very minute particles predominate. In droughts, as already stated, soils which are largely composed of sand or gravel are the most readily affected. In such coarse soils the sum total surface of the grains of which the soil is composed, and the wideness of the interspaces, provides them with but very limited powers of drawing up sub-soil water to the roots of the trees. It may be generally stated that the greater the proportion of very small particles in soils, the larger is the amount of water that can be retained and drawn up. Clayey soils, therefore, naturally retain much more water than a coarser soil is able to hold on to. This, however, is not always an advantage, because the water retained in the soil drowns out the spaces between the soil particles, which would otherwise be partly filled with air. Air is absolutely essential for the respiration of roots, and for the healthy existence of the bacteria in the soil. Cultivation is never more essential than in the case of a clayey soil. By means of proper cultivation the minute particles in a clayey soil tend to cling together, thus coarsening the soil and enabling air to penetrate the soil.

Clay is a very plastic material. It can be puddled, that is to say, so worked up in a wet condition as to be almost non-porous, and puddled clay is therefore largely used for lining drains and the embankments of dams.

Clay soils under tropical sunshine can be very stiff in hot, dry weather, and planters often prefer to do their forking when the soil is wet. Unless lime is then added, or there is a litter of leaves or other green manure to dig in, working over the soil may not aerate it much. There is no soil which can be more benefited by the addition of vegetable humus in the form of green-manuring than a heavy clay soil. This, or the addition of lime, helps very much in inducing the very minute fine particles of soil which are characteristic of clay soils to cling together in larger masses, allowing for larger air-spaces between.

Some readers may have a difficulty in understanding how and why the addition of lime, which is recommended as a great assistance in breaking down and rendering available the mineral salts in soil particles, can have the apparently opposite effect of " flocculating," that is to say, of aggregating the fine particles in clay soils and so rendering them easier to work and more permeable to moisture. One of the ablest writers on agricultural matters, Dr Hall, late of the Rothamsted Experimental Station, deals with this point. The liberty of condensing a few paragraphs out of one of his volumes is taken:—

" The material called clay is characterized by certain properties that are shown when the clay has been puddled, *i.e.*, kneaded when in a moist condition. Water to which a little clay has been added and rubbed up remains turbid for a very long time. Weeks will pass before all the particles settle down to the bottom. Schloesing draws a distinction between the part of the clay (1 or 2 per cent. of the whole) which persists in remaining suspended and the proportion which settles down quickly, and attributes many of the typical clay properties to the jelly-like medium of colloidal matter by which the other defined particles of the clay are surrounded. Later researches, however, show that the colloidal particles are not essentially different except that they are exceedingly fine in texture.

" Fineness of grain is an essential factor, the characteristic properties of clay not being developed except in material the particles of which are less than one five-hundredth part of a millimetre in diameter.

" But, although fineness of grain is a factor, it is probably not the only factor, as may be seen from a consideration of another important property of clay—its power of flocculating or coagulating under the action of minute quantities of various salts. To illustrate this point a few grains of good clay should be rubbed up with several litres of distilled water and the turbid liquid poured off into several tall glass jars. To one of these jars nothing should be added, to two others .018 and .009 gram of hydrochloric acid respectively, to a fourth jar .028 gram of calcium chloride, and to the fifth .058 gram of sodium chloride. The contents of the jars should be shaken up till solution is effected and they then should be put aside to stand. After some time the liquid to which the salts have been added will begin to clear and the clay particles will clot together and fall to the bottom. The jar containing the larger quantity of hydrochloric acid will clear first, the others will clear approximately together, but the jar containing the pure water and clay will remain turbid for many days. If a little of the turbid clay water be examined under the microscope it is just possible to see the clay particles in rapid " Brownian " motion, and if a little salt or acid be then introduced under the cover glass, the particles will be seen to move together and form into little clots or aggregates as soon as they experience the effects of the added acid or salt.

" This aggregating together of the fine particles, which is known by the term of ' flocculation,' may be aided by the use of certain artificial manures. The incorporation of humus or green manures much improves the texture, while the action of lime is particularly effective and is much employed in practice to ameliorate the working of clay soils.

"Lime itself can be shown in the laboratory to possess but little flocculating power, for although its basis is calcium—a highly-effective metal—it is combined as a hydrate which has a deflocculating effect. However, as soon as lime is supplied to the soil it becomes converted into carbonate, and some of it will always be going into solution as bicarbonate, a salt which possesses great flocculating power.

"In practice, the application of such small quantities as a ton, or even half a ton, to the acre have the greatest value in ameliorating the working of clay land. Not only does it move more readily and fall more easily into a good tilth, but, by becoming coarser grained, it allows rain to percolate more freely."

It will thus be understood how it is the case that, while lime is the means of assisting certain beneficial bacteria and of setting free mineral food, it still has, in the form of bicarbonate, an active effect in causing the fine clay particles to cling together, enabling a better aeration of the soil and a freer percolation of water to take place, and greatly diminishing the resistance of the stiff soil to the growth and expansion of the tender rootlets of the trees.

Mr E. J. Russell, of the Rothamsted Experimental Station, puts the case of lime or no lime in the following words: "Injurious and inhibiting factors are of various kinds and form a highly vague group, but some of them must be put out of action by lime because of the striking effect which it has on soil fertility. Indeed, from the vegetation standpoint, soils can be divided into two main classes—those which contain lime and those which do not. So great is the distinction that the practical man has long since made use of a separate name for the latter soils and calls them 'sour,' a term which many writers not altogether correctly interpret as acid."

Sometimes, when a surface-soil is very light and porous, it may well be the case that tropical rainfalls have washed out most of the soluble mineral salts. It is scarcely correct to judge of the quality of the soil of an estate by means of a chemical analysis of portions of such surface-soils. The sub-soils are frequently quite rich in the principal chemical elements required for plant food, and, given a good rainfall, rubber, although possibly hard to establish, ultimately comes away well when the roots have reached deeper soil. This has frequently been found to be the case in Ceylon and elsewhere.

It is a fact, recognized by agriculturists for centuries, that burning soil adds wonderfully to its fertility. Although this method has been long practised, the reason why increased fertility was assured was not understood. The reason is as follows: The effect of high degrees of heat on the soil is to destroy not only the greatest portion of the bacteria present in the soil but also the whole of certain organisms, called protozoa, which feed on these bacteria. The consequence of the burning of the soil is that—after a very short lapse of time—beneficial bacteria multiply without hindrance in the calcined soil and its fertility is increased by the increased rate at which nitrates are manufactured by these bacteria.

What has been termed hot-weather ploughing has been found in some districts of British India to be a means of attaining the same results and one which is followed by a great increase in the fertility of the soil.

Where manures are not available, or are expensive, soil burning would give a good start off to young plants. Where plants are difficult to establish from sourness of soil this is an effective remedy. Kilns are not expensive to build, and the total outlay for burning the earth and transporting it would only amount to a few cents per tree, an outlay which would be amply repaid by the rapid growth of the trees and earlier arrival at the tapping stage.

Some chemists, Whitney, Cameron and Schreiner among them, have recently brought forward the theory that there is an abundance of plant food in all soils; that all soils are composed of practically the same decomposed rocks and are therefore almost identical in character; and that the soil solutions are the same in all cases. Infertility, it is argued, is due to other causes than lack of nutritive compounds, and arises from the presence of poisonous organic compounds in the root excretions of plants.

This theory, although perhaps the net is cast too widely, deserves serious examination. Every agriculturist is well aware that certain plants, such as red clover, cannot have two successive crops taken successfully from the same area. Clover-sickness, arising from some poisonous matter—supposed by many to be excretory, although this is denied by other chemists —invariably affects the second crop. This is one of the reasons why crop rotation is found so desirable by farmers. Fortunately, good drainage, cultivation and the addition of lime will improve almost any soil, just as bad drainage and neglect of cultivation will cause soils to deteriorate. There is good reason for coming to the belief that the character of the bacteria present in the soil becomes altered when the lime contents are reduced below a certain limit and the organisms which prey upon them become unduly multiplied.

The rubber planter having thus realized that the soil is not a mass of dead material, but—although the surface may appear to the limited range of our eyesight bare—is yet covered and intermingled, to a depth of several feet in many cases, with millions of minute plant organisms upon whose healthy existence his crops must ultimately depend, intelligent cultivation should surely follow as a matter of course.

CHAPTER III

BACTERIA, OR SOIL FLORA, AND THEIR RELATIONSHIP TO SOIL FERTILITY

"BACTERIA! What on earth have bacteria to do with rubber-growing?" will have been the exclamation of many when noting the references to them in the last chapter. The answer is short and simple—Everything! If it were not for the active assistance given by the bacteria present in the soil there would be no possibility of cultivating any rubber at all. The rubber trees would be non-existent, and so, in a very short time, would be the rubber-grower himself.

To give rubber-growers some brief information upon the subject of bacteria, so far as these affect agricultural and, more especially, horticultural operations, is the object of this chapter.

It must be recognized that the rubber-growing industry can never be brought to a high plane unless those engaged in it have high ideas of what it may be and should be. The rubber-grower has to take into account an extensive soil flora, the very existence of which was never imagined till within a very recent date, and of whose existence and activities in relation to the successful growth of rubber very few planters know anything at all. Yet it is certain that the rubber-grower of the future, if he is to be efficient, and if he is to attain to an understanding of the elements of the fundamental basis of tree culture, must not only know of the nature and existence of these microscopic soil plants, but he must also comprehend something of the effect of these bacteria upon each other and upon the trees which he cultivates. He should, he must, understand the conditions under which they produce ammonia, nitrites and nitrates, increasing the fertility of the soil, and the conditions also under which certain of them in turn destroy compounds of nitrogen in the soil and reduce its fertility.

For many years after their discovery in the seventeenth century bacteria were regarded as minute animal organisms interesting to observe through the microscope but of no particular importance in the economy of nature. By the middle of the nineteenth century, however, their scientific importance was recognized; but it was the detrimental members of the family which were taken into account, and they were studied only in connection with diseases, and at first more especially those diseases affecting animals. This general reputation given to them was, however, scarcely just, for, fortunately for humanity, the beneficial bacteria far outnumber those which are detrimental in their action. They are intimately associated with processes going on in the soil and water which are absolutely essential to the existence of horticulture. Their function is most important. These micro-organisms play a fundamental part in the processes of nature. Without these microscopic plants these processes would cease, and the culture of rubber trees would become utterly impossible.

During the last thirty years much study has been devoted to them, and it is recognized that they are closely related to the yeasts. They have, therefore, been relegated by scientists from the animal to the vegetable kingdom. The reason, at first sight, may not seem comprehensible, many of them being apparently endowed with the power of motion from place to place. A frequent method of their reproduction, namely, by means of spores, which can survive dried for very long periods, is that of plants rather than that of animals. Their rapidity of multiplication is quite extraordinary. If the rate were continued without interference, one of these bacteria in twenty-four hours would produce 17,000,000 descendants, in forty-eight hours 281,000,000, while the oceans might be filled up with a solid mass of these bacteria in the course of five days, if the rate of increase was permitted to continue without check.

The soil, then, is by no means a dead, inert mass of material, but should rather be viewed as an immense factory in which the most interesting and complex chemical transformations are being incessantly carried on by minute organisms. One can scarcely imagine the labyrinth of minute winding passages and cavities which are always contained in the soil. It has been calculated by more than one writer on agricultural affairs that the surfaces of all the particles in a cubic foot of fine soil would amount to, at least, one acre of superficial extent. A thin film of moisture lines all these internal caves, cracks and fissures. In these minute cavities enormous numbers of tiny bacteria are to be found. Some of these are to be seen under the microscope in active motion, winding their way through the watery films; others are motionless. Their size is extremely minute, and some 1,800,000,000 of ordinary

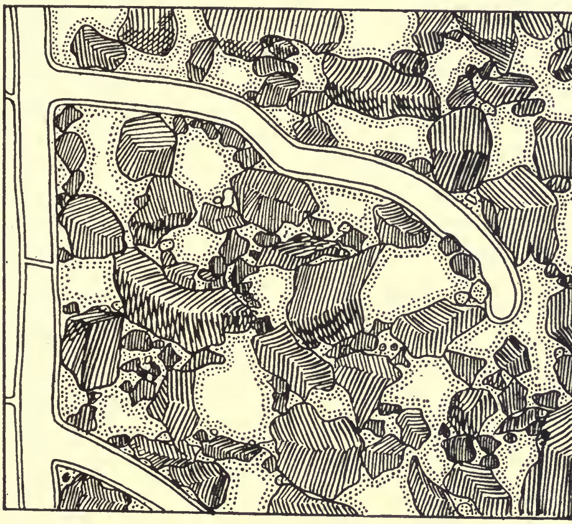

FIG. 2.—Diagram of magnified section of Soil, showing particles surrounded by Water-film, and Root-hairs (modified from Sachs).

bacteria might easily be contained in so small a space as one cubic millimetre of water. The illustration given herewith shows a small patch of ordinary garden soil slightly magnified so as to give an idea of the cavities and spaces which exist even in a fine soil.

Ignoring the many other classes of bacteria, the beneficial bacteria which add to the fertility of soil may be divided, so far as present knowledge goes, into four principal classes :—

1. Those which act on the organic matter present in the soil and convert its nitrogen into ammonium compounds.

This is the first, and in some very acid soils the final stage. Ammonia can serve as plant food.

2. Those bacteria which, in their turn, by oxidation produce nitrites from the ammonium compounds mentioned above.

3. Those bacteria which act on the nitrites, and, by means of oxidation, form nitrates.

4. Those bacteria which procure nitrogen directly from

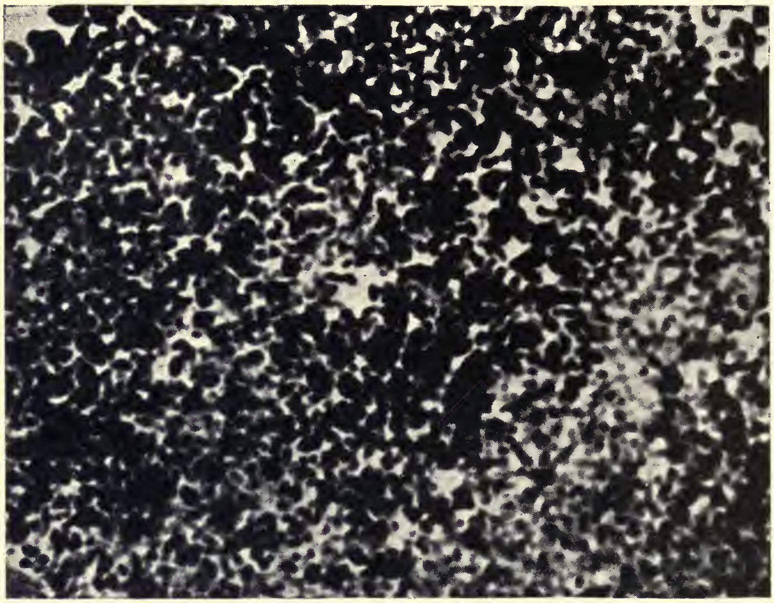

FIG. 3.—Photograph of Fine Garden Soil (magnified 36 times).

the atmosphere, and of these there are two kinds: (*a*) Those living free in the soil, and (*b*) those living in nodules upon the roots of pod-bearing leguminous plants (as peas, beans, etc.).

The fertility of soils is to be measured by the numbers present and by the activity of these beneficial bacteria. It is essential that these beneficial bacteria have a sufficient supply of air in order that they may discharge their functions. In water-logged, sour or dank soil they cannot act. Consequently, by cultivating soil it is aerated, and, being aerated, its fertility is marvellously increased. It is very important that rubber-growers with flat, low-lying land and heavy soils should take very careful note of this fact. Much is lost by neglecting to remedy such a state of matters. The amount of organic matter present in the soil has, of course, a direct relation to the number of bacteria then present. Within limits, the more organic matter, the more bacteria present.

It has been computed that the bacteria in one acre of land give off 165 lb. of carbonic acid each day. Probably, in tropical countries, the amount is much greater. This goes, in part, to

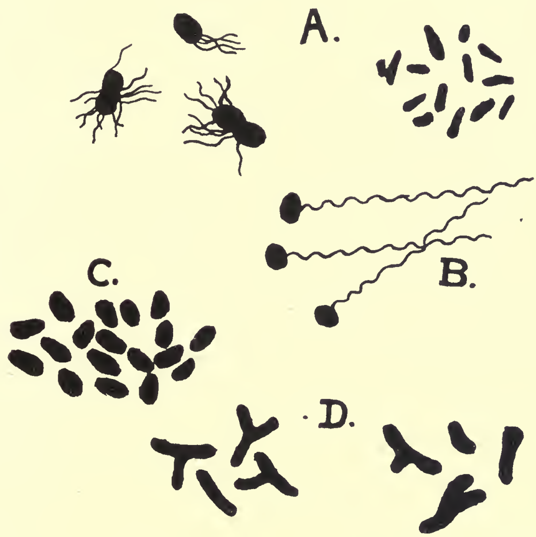

FIG. 4.—Illustration of various Nitrogenous Bacteria, magnified many thousand times. A, two species, living free in soil fixing atmospheric nitrogen; B, a species making nitrite from ammonia in humus, from a Java soil; C, a species making nitrate from nitrite; D, two species found in the nodules of leguminous plants, fixing atmospheric nitrogen.

supply stores of carbonic acid for the green leaves of plants. In part also it renders soluble the silicates and aluminates in the soil, which contain minute quantities of valuable salts.

On the roots of all leguminous plants there are to be found swellings, nodules or gatherings. (*See* illustration of bacterial nodules on the roots of mimosa.) In 1888 Hellriegel and Wilfarth proved that these contained many bacteria, and that these bacteria obtained supplies of nitrogen direct from the air and furnished it to plants in an elaborated form. It was known for many centuries that the cultivation of pea or bean-bearing plants added greatly to the fertility of the soil, but the reason of this was not discovered till the above-mentioned date.

The whole science of fermentation in all its varied aspects

FIG. 5.—Bacterial Nodules on Roots of Mimosa.

is based solely upon the chemical changes affected by bacteria. The bread we daily eat is fermented and leavened by the action of the yeast, otherwise it would be a sodden, unappetizing mass of dough. By the action of bacteria certain sugars are transformed into alcohol; by other bacteria alcohol is converted into vinegar, and so on in instances too numerous to mention.

Experiments made go to prove that this power exists in certain substances which are secreted by the protoplasm in their cells. Certain bacteria have been ground up to a fine powder and subjected to enormous pressures. The juice derived from them was thereafter found to have all the potency in effecting chemical changes that the bacteria possessed themselves. This, however, is not conclusive evidence, as the microscopic spores might very well escape. Indeed, the late Professor Tyndall, Professor Bastian and others found that both very low and very high temperatures failed to exterminate certain bacteria with which they experimented, although their activities were suspended till normal conditions were resumed.

By the addition of organic manures the number of these beneficial bacteria and their activity can be enormously increased and the fertility of the soil much added to.

The presence of lime in the soil has a very important bearing on the freedom with which the bacteria can act. The addition of lime, where the soil is poor in that constituent, or where the soil is soured, or, as in the case of clay, is heavy, has a most beneficial effect. Basic-slag serves the same good purpose. In fact it may be definitely stated that the nitrifying power of the bacteria present in the soil is the factor limiting its fertility more than anything else.

Rubber-planters have hitherto paid scant attention, or none, to this important matter. Yet all vegetation depends for its very existence on the assistance given by the bacteria. The knowledge of this fact ought, at least, to stimulate a desire to see that the soil is maintained in the best condition for promoting the activity of these beneficial bacteria. Water-logged, sour, dank soils encourage the presence of detrimental bacteria, which destroy the fertility of the soil, and also the presence of organisms which feed on beneficial and other bacteria and reduce their numbers, and therefore such conditions of soil should be avoided.

Drainage and cultivation are the chief and best means of ensuring the increased presence and the activity of beneficial bacteria.

When the rubber trees are too closely planted it is almost impossible to have any cultivation of the soil between the rows of the trees. The soil in such circumstances is a mass of roots and no tillage is possible. Thus, the soil is apt to become sour and dank, the beneficial soil flora can scarcely exist, their numbers are inevitably greatly reduced and the conditions which make for high fertility are absent.

Almost everything alive breathes in oxygen and gives off carbonic acid. The more oxygen there is in a cultivated, aerated soil, the more energetic and vigorous is the life of all the beneficial bacteria in the soil.

The absolute necessity of cultivation and good drainage in order to secure thorough aeration of the soil will be better understood when it is comprehended that the process of nitrification may be said to be an oxidation process and to mainly consist of successive releases by the various bacteria of hydrogen atoms from the organic matter treated and replacement of these atoms with atoms of ogygen. The better the cultivation the more is hastened the oxidation of the organic matter in the soil, and thus fertility is facilitated.

All soils, whether fine or coarse, light or heavy, are much benefited by cultivation. Without cultivation there never can be high fertility, and the best can never be got out of the land. In its original sense, the word manure, from the Latin word *manus*, the hand, meant to work up by hand, *i.e.*, to cultivate. This meaning of the word will be found in Defoe's celebrated book, *Robinson Crusoe*, where Crusoe states, speaking of his small crops, that " the ground that I manured or dug up for them was not great."

The mere surface scratchings of ordinary weeding of the soil are not cultivation in the right sense. Cultivation goes deeper, and does not, or at least should not, cease when weeds cease to grow under the shade of the foliage of the Heveas. Neglect of this has been the mistake of the management of many of the older plantations and they have suffered very seriously indeed thereby.

If rubber cultivation is to be efficiently conducted in the future, due cognizance must be taken of the action of bacteria and the influences they exert. Knowledge of this kind throws a flood of light upon the problem of—How to make the best of a rubber plantation. It touches the question at all points:

planting distances, cultivation of the soil, liming, manuring and drainage all assume a fresh interest when they are considered from this point of view. The reason " Why? " of many things is thus made clear, and calls for the careful attention of all rubber-planters who take, or who desire to take, an intelligent interest in their work. A higher degree of efficiency than in the past is being demanded from the managers of rubber estates, and without intelligent knowledge that can scarcely be forthcoming.

The great Napoleon is said to have remarked that when he died people would find written upon his heart the word " Moscow." So upon the heart of every good planter should be indelibly engraved the word—*Cultivate.*

CHAPTER IV

THE SEED AND ITS FERTILIZATION

THOSE who have debated the old vexed question—Which came first: the hen or the egg?—will admit that if one wishes to produce a Hevea tree, the seed is the first necessity. The seed, however, presupposes a parent plant, and, it may be said, a father and a mother. The Hevea tree, as all planters are aware, bears flowers, and in these flowers are to be found the fathers and the mothers of the seed that are to be. The flowers, which are white, with a fine-lobed calyx or cup, are found at the tips of the branches in small bunches. The male and female flowers are found together in each of these bunches. In the male flower, the stamens—which are in reality leaves reduced generally to filaments which bear, in lobes at the end, the pollen-grains, the male element of the plant—unite in the centre, forming one column. In the female flower each ovule is divided into thin-walled cells, and surrounded by them is the ovum, the female element.

Fertilization in the case of the Hevea is by means of wind-borne pollen, that is to say, by a form of cross-fertilization. Few of the higher members of the vegetable kingdom are self-fertilized. It is a general law of Nature that vigorous growth and healthy life can only be secured when cross-fertilization has taken place. All planters know how, when the Heveas are in flower, the whole air is full of the scent from the pollen which fills the air in the neighbourhood of the trees. In this way cross-fertilization is secured, the pollen from one tree being wafted to others.

When the ovule has undergone certain changes as the result of fertilization, it becomes a seed, and, granted favourable conditions, will germinate and produce a plant. The young plant will not be produced from the whole seed, but only from a part

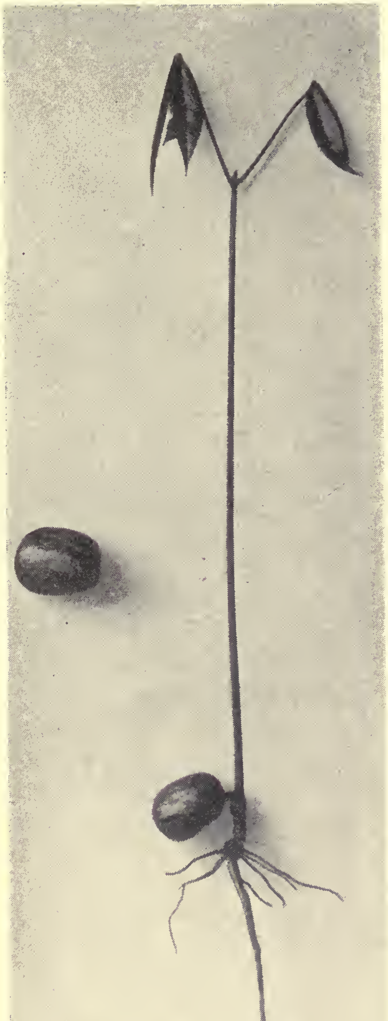

FIG. 6.—Seed and Seedling Plant.

of it. That part is called the embryo. When germination takes place the embryo pushes its way out of the seed; the young rootlet, called at this stage the radicle, turning down, and the young stem pushing its way upwards towards light and air. Just as the embryo of a chicken has a store of food upon which to feed and develop before it leaves the egg-shell, so the embryo of the young Hevea plant has a sufficient store of food inside the seed to supply its needs until the rootlet has attained a proper hold of the soil. On the young stem which pushes its way upward through the soil to light and air are two small leaves, formed in the seed and helping the young plant through its early stages, which later on shrivel up and die. It will be seen, therefore, that just as the acorn holds in miniature the future oak tree, so in the seed of the Hevea are to be found in the embryo the root, the stem, and the first leaves of the future tree.

The seed of the Hevea usually germinates in from eight to ten days. Seeds which take longer to germinate show a weak vitality and usually produce sickly plants. Trees labour under great difficulties in bringing up their families. These difficulties arise from the fact that trees—like the great majority of plants—have not the powers of locomotion, and therefore must remain securely anchored to the spot where they originally took root. Under such circumstances their seeds, if simply dropped down under the heavy shade of the foliage of the trees, would perish. The tree has, therefore, to do the best it can to give its children the prospect of a fair start in life in a wider world.

In the case of the Hevea, as all rubber-planters are aware, this start in life is secured in a very extraordinary manner. The pods of the Hevea contain three seeds, and the Hevea has so cleverly contrived things that these pods explode with great violence. This explosion scatters the seeds to a distance of twenty yards or more, and therefore well outside the radius of the shadow of death cast by the foliage of the parent tree. This is one of the most astounding examples of the ingenious devices conceived and carried out by plants. Before mankind had arrived at the use of slings and stones, or bows and arrows, the Hevea tree had devised and developed an able and efficient scheme of projectiles all its own.

The seeds of the Hevea have—as stated elsewhere in this book—a very feeble hold on existence, and unless very promptly planted, perish. There are, however, many trees and plants, the seeds of which have great vitality and which can be kept for months, and, in some cases, even for years and yet germinate thereafter if placed in suitable surroundings. This circumstance has given rise to many scientific discussions as to what the nature of that life can be which can remain apparently suspended for such long periods. Wheat-grains are a well-known case in point. While it is just a popular error to suppose that the wheat-grains buried along with Egyptian mummies three, four or five thousand years ago can ever germinate, yet there is no doubt but that grains of wheat can be kept for at least two or three years without entire loss of vitality. Many hard-shelled seeds and nuts enjoy the same tenacious hold on existence.

The seeds of the Hevea are of fairly large size, and as they contain a great deal of oil, many projects for collecting them and crushing them in oil-mills have been mooted. So far nothing serious has been attempted in this direction, nor does there appear to be any present prospect of a practical outcome in connection with it.

CHAPTER V

THE ROOTS OF THE HEVEA

THE roots of a tree are not inferior in importance to any other part of its bodily structure, and the intelligence which they display in avoiding or overcoming obstacles and in extending themselves in the one direction in which water is to be found, has often been remarked upon. So much is this the case that the late Dr Oliver Wendell Holmes once described a tree as an intelligent animal with its tail in the air.

The roots of the Hevea present the appearance of a series of brown branches. The main or tap-root is a continuation of the original rootlet of the seedling, which sends out numerous branches—lateral roots—as its growth proceeds. The lateral, or, as the planter would say, "feeder" roots, have as their main purpose, in addition to assisting in the support of the stem and branches of the tree, the supplying in a state of solution of those various chemical elements necessary for the building up of the structure of the tree which are not manufactured by the leaves directly from the atmosphere. These lateral roots may be confined largely to the surface in stiff, clay soils, or in soils badly-drained and aerated, and soil-wash or drought then hit the tree with force. In permeable, well-aerated soils one may find, as it were, four or five successive layers of lateral roots springing from the tap-root, the lowest at a good depth, so that the tree is better defended against the above dangers, while it is manifest that a much more extended feeding-ground is at command, a condition leading to better growth and ultimately, of course, to a higher yield of latex. The tap-root reaches down deep into the soil, and serves the double purpose of securely anchoring the tree in the soil, and of absorbing and acting as a conduit for the water-supplies so necessary to the growth of the tree. The older portions of the root-system are covered by bark which prevents the absorption of water, but the outer shells of the young roots, and certain hair-like offshoots springing from them (root-hairs), possess thin walls through which water is sucked in. Root-hairs have a corroding action upon the soil particles by virtue of an acid they excrete, and the mineral food they dissolve, along with that already in solution, passes into them with the soil-water and then into the cells themselves. From these outer cells the water carrying the mineral food passes from cell to cell on to conducting-tubes in the interior of the roots, and thence up through the stem till it reaches the leaves.

The structure of the older parts of the root-system closely resembles that described in the next chapter as being that of the stem.

A good root development is essential to the welfare of the tree. While the foliage manufactures much of the food required for the growth and the renewal of the cells, the salts necessary for the tree's existence and continued growth are only derived from the soil.

The green colouring-matter in the leaves of the tree, called chlorophyll, for example, could not be formed if there was no iron in the soil which could be dissolved and thereafter absorbed by the roots, and in due course reach the leaves. Leaves might grow on the branches, but they would not be green leaves, and if not green they could not, with the assistance of the sunlight, convert the carbonic acid gas of the atmosphere into carbon compounds to build up the structure of the tree, and there would be no growth. The quantities required of some of the mineral salts may be but small, yet they are thus absolutely indispensable.

The more meagre the spread of the roots, the more restricted the feeding area of the roots. A widespread area means greatly-multiplied stores of food-stuffs at the disposal of the tree. In stiff clay soils the spread of the roots is much restricted, unless the soil is loosened by cultivation. Where trees are closely planted the roots of the trees have to contend with each other for space and they become matted together. Wide planting is as essential for the healthy development of the roots, and therefore, ultimately, of the tree, as an abundance of light and air is for the foliage.

Roots must have sufficient supplies of air in the soil for breathing. When the soil is water-logged the roots infallibly suffer. The importance of a thorough system of well-laid-out drains can scarcely be over-rated, especially on flat, low-lying estates.

While the roots have willing friends in the soil, the beneficial bacteria which supply them with the nitrates and ammonia necessary for food and growth, enemies also lurk there. Deadly fungi lie in wait, ever seeking an opportunity to attack where there are decaying roots of jungle trees to harbour them, or where there is soured soil. The roots of the Hevea, unable to retreat, fall easy victims unless speedy assistance is given. The root idea of every rubber-planter ought to be cultivation. In a well-aerated soil fungi have less opportunity for their malignant action. One would think that it would be evident that when there is close-planting and the roots occupy, nay, crowd, all the available space, there can be no possibility of cultivation. Yet, to this day, well-known planters, and especially Ceylon planters, actually advocate planting 10 feet by 10 feet, attempting to make up for this closeness by cultivating and heavily manuring the soil. It makes one feel that the conditions cannot be properly understood.

If one considers a tall Hevea tree 40 or 50 feet in height—and under favourable circumstances a Hevea grows to 80 or 90 feet high—it will be seen what a serious problem the tree has to face to supply not only the cells of the roots and stem with sufficient supplies of moisture, but even the furthest leaves at the tips of its branches. Yet this is necessary. Without supplies of water the leaves cannot manufacture food. The trees have no mechanical pumps at their service wherewith to raise water to such a great height. How, then, do they succeed in supplying their requirements? By two methods at least working together; by means of root pressure and by means of evaporation.

The outer cells of the roots and the root-hairs have their walls constructed so as readily to absorb water when enveloped by the moist earth. When the water has entered these cells, it cannot pass outwards again. The cells in question behave as if they have valves which permit the entrance of fluids from without, but which promptly close down on any effort of the water to escape by the apertures where it entered in. The water is drawn through the walls of the cells and their root-hairs owing to the great avidity of the cells for water, an avidity largely due to greater concentration of salts. This power is greater the nearer the cell is to the centre of the root. The cells of the roots becoming distended with fluid, their elasticity tends to force it out, but inwards towards other cells, owing to their avidity for water. Each successive cell becomes a receiving-vessel for the fluid in turn, and, being constructed by the great architect of Nature upon the same principle, in turn is charged and discharged. This tendency of a cell to absorb moisture from one below better supplied is just as a piece of sponge squeezed dry would absorb moisture from a wet piece in contact with it. The quantity of water passed through a plant in a comparatively short time is very large.

To raise sufficiently-abundant supplies, the root-pressure which inaugurates the work needs to be supplemented. This is done in part in the leaves by means of evaporation. The under sides of all leaves of trees, and to a much less extent the upper sides, are full of small openings through which superfluous water is got rid of. The cells of the leaves evaporate into the air between them most of the water that has brought the mineral food from the roots, and this moisture finds its way out through the openings. While supplies of moisture are abundant, evaporation freely takes place, yet undue evaporation is prevented during very hot, dry weather and during the prevalence of drying winds. At such times the lip-like cells at the openings on the under sides of the leaves, themselves affected by the drying action, close in together, so narrowing the openings, to prevent waste of moisture. There is no suggestion that absorption of moisture for the leaf-cells may go on through the stomata. After a shower of rain, or when a plant is watered, it having perhaps been suffering from drought, a general freshening-up is shown. A common error is to suppose that the plant has actually absorbed the water by means of the leaves and stem, whereas it has absorbed it through the roots, the humidity of the air contiguous with the leaves preventing in addition any further great loss of water by evaporation from the interior of the leaves.

The passage of the water through the conducting-tubes in the wood of the root, stem and branches to the leaves has to be accounted for, it being clear that the root-pressure and the evaporation through the stomata cannot be powerful enough to propel the water the whole distance. Unfortunately, how the water is enabled to travel this distance is not yet decided, for of the various hypotheses advanced none receive general acceptance.

The whole complicated process of water-supply and discharge is admirably conceived, and is carried out by these minute living-cell engineers working together in perfect harmony, as if each cell seemed to understand very well not only its own duty but that it was being backed up by its neighbour's activities.

CHAPTER VI

THE STEM

THE stem or trunk of the Hevea is the portion of the tree which comes nearest to the planter, and which interests him most. How very interesting the stem of the Hevea can be, when rightly viewed, is a subject of which some planters are very highly ignorant. To many planters the stem of the Hevea is the stem of the Hevea and there is nothing more to it. They recognize, of course, that the stem is composed of various layers: *i.e.* (1) The heart-wood; (2) the sap-wood; (3) the cambium; (4) the inner layer of the bark (cortex) containing the laticiferous vessels; (5) the outer layer of the bark (the bark proper). To them " the age of miracles is past," and wonders are worked before their eyes—without their being aware of the fact.

One writer says: " As the untutored savage explains the movements of a watch by attributing them to a spirit which has entered into it, so many writers hold that the activities of living matter are due to some special and mysterious vital force. They attempt to bridge the gaps in our knowledge by giving them a name. This is no scientific method. Science advances by explaining, that is, describing, the unknown in terms of the known."

This is most amusing. If describing a thing that is unknown by giving it a title is not doing exactly what he complains of, the English language is hard to be understood. One might know the name well enough; it might be Tom, Dick or Harry, but it would be no explanation of electricity, for example, let alone of the mysteries of life.

The writer goes on to say: " If vital force is merely a general term for these new properties manifested in new mechanisms of increasing complexity, there is no harm in it; certainly living matter must display properties not found in simpler substances, but it has no intelligible meaning if used to denote some force added, so to speak, from without, over and above the ordinary properties acting on the physico-chemical mechanism but not of it."

The English might be improved, but the meaning is intelligible. It is simply this, that chemistry accounts for the things he does not know. Life is one of these things; he does not know what it is, as he admits, but is satisfied that it is a matter of chemistry. The self-sacrificing love of a mother for

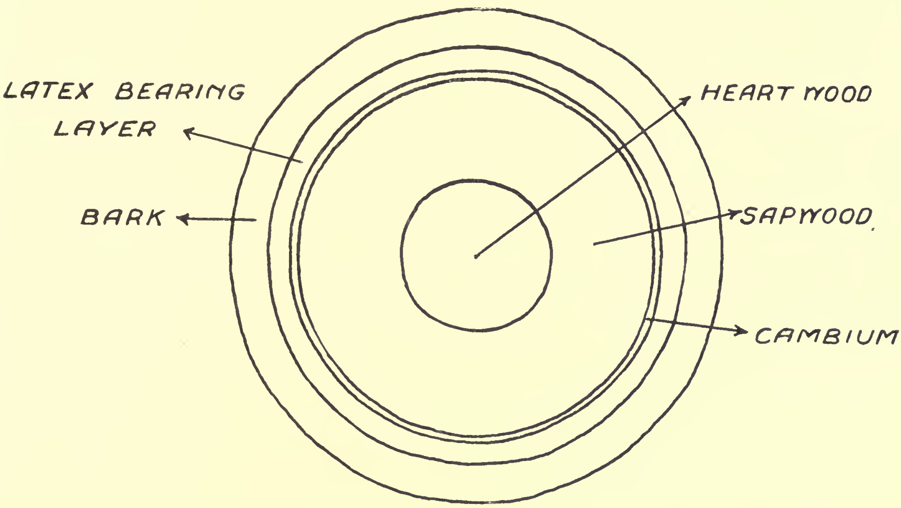

FIG. 7.—Rough Diagram (not to scale), showing the position of the Various Layers in the Stem.

her child is also, no doubt, equally capable of similarly lucid explanation—it is purely a matter of chemicals.

After all, although Thomas Carlyle might have had no claim to a knowledge of advanced chemistry, he was a man of much more insight. In *Sartor Resartus* he has the following passage: "All visible things are emblems. What thou seest is not there on its own account, strictly speaking, is not there at all! Matter exists only spiritually and to represent some idea and body it forth."

Henri Bergson, in his great work, *Creative Evolution*, says: "Organization can only be studied scientifically if the organized body has first been likened to a machine. The cells will be the pieces of the machine, the organism their assemblage."

If we apply this description to the Hevea tree it will at once be seen to be a ludicrously inadequate conception. Even if we regard the tree as a factory full of diverse machinery it gives quite an insufficient idea of the facts of the case. To arrive at a true understanding of the realities we must rather imagine the tree as a well-equipped city, full of activity, and with a large and thriving population. If we portray to our minds such a picture we shall find that there are present, and in active operation in the organization called a tree, what we might legitimately describe as gas-works, train services with well-laid-out routes and apparently many thousands of attentive and intelligent porters, and pumping installations with invisible engineers to attend to them and to execute any necessary alterations or repairs. There are chemical works in the tree-city, where a large number of chemical products are manufactured, such as various colouring matters, starches, sugars, proteins, resins, oils, and, of special interest to the planter, caoutchouc. There is also a well-laid-out drainage system.

With regard to the gas-works, which we have mentioned as being present in the tree-city, the leaves, during all the hours of daylight, are constantly at work, taking in carbonic acid gas from the atmosphere, turning out oxygen gas and manufacturing carbon compounds. The gas-works of our cities and towns are much more crudely conceived and less efficient.

Throughout the stem of the tree there are, as has been stated, well-laid-out routes of what might be described as tubular railways. There is the route *via* the sap-wood, where the food in solution derived from the soil is sent up to the manufacturing centres situated in the leaves of the tree, and to other parts. Another important route to serve this great organization passes downward through the bast in the inner bark, carrying the manufactured food in the form of sugar and other products. The bast lies close to the wood and contains, among other elements, a system of conducting tubes (sieve-tubes). There are also what are known as the medullary rays, vertical plates of cells running through the wood and inner bark in the direction from the centre of the tree to the outside and acting as a system of storehouses and passages for food supplies. Beside the medullary rays there are many cells, distributed especially in the inner bark and outer wood, that receive and store up reserve materials.

Invisible porters, as has been stated, must be in attendance, for, as the supplies advance, a constant distribution goes on. In the warehouses on the route stores of reserve food are laid up for the use of the tree from the train wagons as they pass by on the downward route and stop at each station. The sugars, and also some proteins, soak through the walls of the leaf-cells into the downward track, the bast, and travel on through the protoplasm of what are called the sieve-tubes; from these they soak again through cell-walls into the ultimate storehouse, but the sugars are not deposited as such, being changed to starch. And on the upward route the pumping installations, elsewhere referred to at greater length, are of extraordinary power, and can lift supplies of water containing salts in solution to comparatively greater heights than the machine-pumps constructed by human engineers would be able to accomplish.

The well-known author and man of science, the late Grant Allen, compared such a tree to a hive of bees—an intelligent community working in co-operation and engaged in the most diverse labours for the common good. He showed how the individual members of the hive—the workers, the drones and the queen-bee—all had their counterpart in the organization called a tree, and that the resemblance was by no means fantastic. The task of the tree, however, is much more complicated and varied in its scope than that of the hive.

Every cell is a super-man. During recent years many chemical substances found in plant or animal tissues have been formed synthetically by chemists by the operation of chemical methods. While, however, in trees such substances are formed by chemical action at ordinary temperatures, the chemist can only form them, or rather something resembling them, by means of high temperatures or the action of powerful reagents. There are no German chemists who can compare in intellectual ability with those at work in the tree-city.

As Tennyson said of the flower which he had picked out of the crannies of the old stone wall:

> " I hold you here, root and all, in my hand,
> Little flower—but if I could understand
> What you are, root and all, and all in all,
> I should know what God and man is."

The main function of the stem of a tree is to support the foliage which it produces, and to serve as a means of communication between the roots and the leaves. As has already been stated, and as will be seen from the diagram given here, the stem of the Hevea tree is composed of various layers: (1) The heart-wood; (2) the sap-wood; (3) the cambium; (4) the inner layers of the bark (cortex), in which lie the laticiferous vessels; and (5) the outer layers of the bark (the bark proper).

Heart-wood.—The heart-wood, which, as its name denotes, forms the centre of the stem, is dead, and contains no living cells or protoplasm. As the coral island is built up by successive generations of living coral cells on the dead bodies of their predecessors, so have these patriot cells of the heart-wood perished, that over their dead bodies fresh troops of cells may proceed to build the tree-city. Trees of nearly every species can continue to flourish and show no signs of decay although the heart-wood may have rotted away or be eaten out by white ants.

Sap-wood.—The layers of sap-wood are composed of tubes (vessels) and of living cells, and surround the heart-wood. In trees of larger growth, like the Hevea, it forms a thick ring, and helps to account, to a considerable extent, for the great vitality of the Hevea trees. It is through the vessels in the sap-wood that the water and nutrient salts derived from the roots find their way upwards to the leaves and other parts of the trees.

Cambium.—The cambium layer, which immediately overlies the sap-wood, is very thin, probably not more than the thickness of an ordinary sheet of paper. Yet it forms one of the most important sections of the tree. It is another exemplification of the fact that dimension is often in inverse ratio to importance. When bark is torn away from a tree, the cambium, being very delicate, is ruptured, and appears as a slimy

FIG. 8.—A One-year-old Hevea.

layer on the surface of the wood. This cambium-layer is full of intense life and activity. It is the layer to which the increase in thickness of the stem, branches and roots is almost entirely due. On its inner side it is continually adding cells to the sap-wood, some of which join together to form conducting-tubes, after losing their protoplasm, while on its outward side it is always producing additional cortical cells, some of which form laticiferous (latex-bearing) vessels, others sieve-tubes, etc. It is easily wounded by careless tapping, and this, as stated elsewhere, is resented by the cambium, and is one cause of the formation of swellings and abnormal growths.

Latex-bearing Layers.—These are found, along with the bast, in the inner bark (cortex) of the tree near to the cambium. Alongside the laticiferous vessels are found the " sieve-tubes," through which are conveyed downwards the food manufactured by the leaves. Accompanying these are cells that probably serve as temporary storehouses of reserve food for the use of the tree. What the uses of latex are to the plant has long been a matter of dispute. Some hold that the latex is excretory matter, of no further use to the tree, while others stoutly object to this view. It seems reasonable to suppose that the latex is incidentally of some service to the tree, whether for temporarily protecting wounds or as a protection against the attacks of animals, insects or disease.

Outer Bark (*or Bark Proper*).—The coarse, dark-coloured, dry bark on the outside of the tree acts as a protective shield for all living cells within the inner bark, cambium and wood of the tree. It resembles the outer walls of a fortified city. The bark is being constantly attacked by fungi and other enemies of the tree, and has to bear the burden of the defence. Just as the engineers of a beleaguered city would do when their outer defences were breached by an attack, so the tree sets itself actively to reconstruct its walls, adding fresh bark where any has been injured or cut away.

CHAPTER VII

THE FOLIAGE

LEAVES are formed at the apex of the twigs of the tree in such manner that the youngest leaves on the twigs are always those nearest the apex. The chief function of leaves is to absorb carbonic acid gas from the atmosphere. Carbon and oxygen in this gas is worked up with hydrogen and oxygen, found in the water sent from the roots to the leaves, to form sugars and starches. This process, which is called carbon assimilation, can only take place in sunlight. Every tree, therefore, endeavours so to arrange its leaves that they will catch the maximum amount of light. As the leaves are responsible for the carbon assimilation of plants, the more luxuriant the foliage is the greater is its capacity for manufacturing food for the tree. Without abundant foliage the growth of a tree is necessarily much hindered. The mistake of close-planting is thus obvious. A poor spread of foliage is inevitably the consequence of close-planting.

As stated, it is by the leaves of plants and trees that the carbonic acid gas is absorbed by the air and worked into carbon compounds, and they discharge part of the constituent oxygen of the gas into the air, and retain the constituent carbon of the gas in their tissues. The rapidity with which plants do this has been illustrated by a French scientist, Boussingault. He took the growing branches of an oleander plant and enclosed them in a glass vessel, and through the vessel passed a current of air, which was subjected to careful analysis both before and after its passage through the vessel. By measuring the leaves and analysing the air passing over them he found that, under exposure to sunlight, there was an absorption of carbonic acid from the air at the rate of 56½ cubic inches per hour, or a fixation of carbon at the rate of 11½ grains per square yard of leaf surface exposed, thus proving the extreme rapidity with which the absorption of carbonic acid from the air, and the retention of its carbon, actually take place.

Ordinary atmospheric air consists substantially of two different kinds of gases, one nitrogen and the other oxygen. Carbonic acid gas is a compound of the solid substance carbon with the gaseous substance oxygen. Carbonic acid is present in the atmosphere, but the proportion is but small. If one were to build up a column out of two thousand five hundred penny-pieces it would be about 15 feet in height. If one of the pennies were removed from the column that would represent the proportion of carbonic acid in the atmosphere. Overlying an acre of land there are about 20,000 lbs. of carbon in the form of carbonic acid gas.

To those who find difficulty in understanding how an invisible, intangible thing like carbonic acid gas can be converted by the foliage of a tree into solid carbon compounds, the following explanation may be useful. There are three states of matter: the solid, the liquid and the gaseous. Solids possess volume and shape, liquids possess volume but not shape, while gases possess neither fixed volume nor shape. A little reflection will make all this clear. In the case of a solid object, such as a watch, the size and shape are easily ascertainable. In the case of a liquid, such as half-a-pint of beer, the volume is easily ascertainable, but there is no shape. The half-pint can flow away into a plate as readily as fill a tumbler. Gases, having neither shape nor fixed volume, disperse throughout any vessel, however large it may be. A solid object may pass into a liquid or gaseous state, and gases can be made to assume solid forms. In each form there exist molecules of matter, but in a gaseous form they are less united and more distant from each other than in the case of a liquid, or still more of a solid. A familiar instance of the relations between solids, liquids and gases is as follows: When one volume of oxygen combines with two volumes of hydrogen the result of the combination of the two gases is the liquid—water. Given a temperature low enough the liquid water is converted into the solid—ice, and the processes can be readily reversed.

The leaf (including the blade of grass, which is a form of leaf) is the fundamental food-factory of the world, upon which all animal life necessarily depends. The skins of the leaves are perforated by a large number of minute holes or pores, which permit free access of air into the inside of the leaves. A thin film of water is always present on the surface of the cells inside the leaves, and this dissolves the carbonic acid gas, which is then absorbed into the cells and acted upon.

The cells of the leaves, especially the upper cells, contain small green bodies which are termed chloroplasts. These chloroplasts are able to use the energy of the sunlight to supply the chemical energy necessary to bring into combination the elements that go to make starches and sugars. Though the mineral salts brought up from the roots do not enter into the composition of starches and sugars, certain of them must be present to play a part in their manufacture. When darkness falls the leaves stop working, just like a factory in which the engines have been stopped, and, therefore, operations must cease. It is only during daylight, and especially when the sun is shining, that the manufacture of the simpler plant-foods from carbonic acid gas can proceed. When there is an absence of light, such as is caused by close-planting, leaves which are always in shade cannot perform their work; they die off and fall away. The tree is thus something like a steamship which, while it has a dozen furnaces and boilers, is reduced to working with two or three, and can only proceed at quarter-speed.

The chloroplasts are, as yet, but little understood, and the marvels they perform are still something of a mystery. They seem to bear some analogy to the bacteria which work so actively in the soil to supply the roots with nitrogen in the form of salts in solution, and also in some degree in the form of ammonia. For the growth and nourishment of the tree there are thus active processes, little comprehended, yet working in combination.

One more fact should be noted. It is a common error to imagine that plants do not breathe in the way that animals absorb or inhale oxygen and give out or exhale carbonic acid gas. This process of "breathing" should not, however, be confused with the exchange of gases in carbon assimilation, in which it is carbonic acid gas that is absorbed and oxygen that is given out. During the day the latter process swamps the former, and any oxygen required in the leaf is obtained from that set free in the leaf, while the carbonic acid gas produced is

Fig. 9.—A Three-year-old Hevea.

consumed internally. The result is that in the daytime only oxygen and no carbonic acid gas is given off. When it is dark, carbon assimilation ceases, but not the process comparable with breathing in animals. Thus oxygen is then absorbed from the atmosphere and carbonic acid gas exhaled. Therefore the old idea that plants were dangerous in a room at night, though healthy in the daytime, like so many other old notions based on observation, was correct from a scientific point of view.

As every planter is aware, there is a season of the year when growth is arrested and the trees winter, as it is called. Growth in living creatures, plants included, is not a continuous increase; there are, necessarily, periods of rest and recuperation. It is so with the Hevea, as with other trees. Before the time comes for the period of recuperation and, therefore, for a temporary cessation of the process of manufacture of the food-supplies upon which growth is built up, all materials that may be of further use to the tree gradually retire from the cells they occupied in the leaves down the leaf-stalks to the twigs of the trees. The leaves, in the cells of which remain only a lifeless fluid, turn yellow and then brown or red. And thereafter the time comes when the connection between the twigs and the leaf-stalks is weakened by a growth of corky cells across the base of the leaf-stalks, which thereby becomes brittle, and a breath of wind brings the leaves fluttering to the ground. With the corky cells the tree closes the doorway against fungi on the watch.

From the foregoing descriptions of the wonderful structure of the Hevea it will be seen that while science explains much of mystery in Nature, it never—no, never—affords or can afford any rational explanation of the real mystery. What has been aptly called " the solvent touch of science " may resolve for us something of the construction of plants, something of the materials employed in their wonderful structures and much of interest in methods, but to accept these tentative interpretations and to say that that is all would be intellectual bankruptcy. The greater the magnifying power of the microscope the more of marvel becomes oppressively apparent.

Life may sometimes appear as grey as a dull winter sky, but a study of Nature brings out a radiant rainbow, stretching from shore to shore and reaching to the very sky.

CHAPTER VIII

LAND GRANTS

Terms upon which Land is Obtained and Held

THE conditions upon which land is obtained vary very much according to the country. In Ceylon land is generally acquired by purchase, either from Government direct or from some private holder who has previously obtained a title from Government. The land is freehold, and, the price paid, there is usually no annual rental to provide for. There are, of course, cases of land being held on lease from the owner of the freehold, but these are not very common. Native titles are not a secure holding as a rule, and should not be accepted without first obtaining from Government what is known as a C.Q.P., *i.e.*, a Certificate of Quiet Possession.

In the Federated Malay States and Straits Settlements such things as freehold land are comparatively rare, although they do exist, and land is now acquired from Government, subject to an annual rental of $1.00 per acre for the first year, and thereafter at the rate of $4.00 per acre. Many of the old companies, of course, hold land on very much better terms than these, mostly averaging fifty cents per acre, but no grants are now issued on such terms.

In Sumatra there are duties to be paid to Government before a title is issued, and these, while varying in different districts, usually average about G.3.00 per acre, the proceeds being divided between the Government and the local native Sultan. In addition there is an annual rental to be paid, equal to one shilling per acre, which is also divided between the Dutch Government and the local Sultan. Leases are for seventy-five years and are renewable.

It should be borne in mind that, in Sumatra, grants of land are always subject to native rights as to fruit trees and to

FIG. 10.—A Thirteen-year-old Hevea.

kampong lands, and that these rights are sometimes extremely troublesome. There is a scale fixed by Government showing the rates at which these fruit trees growing wild in the jungle must be acquired. By means of private bargaining, however, the trees can sometimes be acquired at half, or less than half, these scale rates. These fruit trees are not necessarily trees bearing fruits, but include such trees as the *Ficus elastica*, which the natives have been in the habit of tapping for rubber on their own account. Their presence is a great hindrance to the operations of felling, and more especially of burning, as they must not be wilfully injured. The natives have also a right to walk into the plantation and visit these trees whenever they feel inclined to do so, and this is very undesirable. It is, therefore, much better to endeavour to acquire the trees, if possible, at a reasonable figure.

At least one large company came to grief over this matter. The property was a large one, in a good district of Sumatra. There was a very large number of *Ficus elastica* trees on the property, and a glowing report was obtained, which stated, among other things, that a large output of rubber, amounting to many thousands of pounds per annum, could be obtained by tapping these trees. The revenue from this source, it was estimated, would be amply sufficient to pay fair dividends till a large area was brought to bearing under Hevea rubber. The *Ficus elastica* trees were there all right, but when the management of the company started to tap them they were warned off. They then, for the first time, ascertained that these trees were the sole property of the natives, whose rights were guarded by the laws of the Netherlands Indies. They then became acquainted with the fact that, if they desired to tap these trees for the purpose of obtaining a revenue, this tapping could only be done after purchasing the trees according to the scale fixed by the Government.

As it was essential to the company's existence that the trees should be secured in order to have the means of obtaining the revenue stated in the prospectus, instructions were sent to buy up the trees from the natives. These negotiations took a considerable time. The number of the trees was very large, and the purchase money made a heavy drain on the limited capital originally provided for the purpose of clearing the estate, planting it up with Hevea rubber and bringing the rubber to bearing.

The worst was yet to come! The wily natives, knowing well that a purchase of these *Ficus elastica* trees was in contemplation, had, in the interval, slashed the trees nearly to death in order to get the last ounce of rubber out of them. Thus, when the directors of the unfortunate company had at last acquired the trees, it was only to find that it was vain to expect any yields of rubber from them until, after the lapse of some years, the trees should have recovered themselves.

In Java very little land is now obtainable direct from Government, and that only at high elevations. Estates therefore have to be acquired by purchase from private owners or from other companies. Rentals vary more than in Sumatra. In many districts one shilling per acre is paid, but in long-settled, populous districts, such as Malang, up to five shillings per acre and even more is sometimes paid.

CHAPTER IX

ELEVATION

RUBBER is grown as high as 4000 feet in Southern India, but, as might be expected, the rate of growth has been extremely slow and the yields of latex from trees of quite a respectable age are very meagre indeed.

In Ceylon rubber is grown to elevations of 2000 to 2500 feet on the hillsides. At the lower of these two elevations the rubber does fairly well, but takes a year or two years longer to come into bearing than in the low-country estates. At a height of 2500 feet the rubber trees look very backward for their age and are sorely tried by the winds which are prevalent. It is questionable whether the returns of latex will ever be sufficiently large to cover working expenses and yield a profit.

In Sumatra East Coast, on the high hills behind the Serdang district, there are several rubber plantations. When last visited the rubber had a distinctly pinched appearance, and prospects did not seem very hopeful.

In Java also there are some estates planted from 1500 to 2000 feet above sea-level. While the growth seemed really quite fair and much better than in the before-mentioned instances, the trees did not seem to tap very well, the amount of latex in the cups from good-sized trees being somewhat disappointing.

There are other crops than rubber, such as tea and coffee, for which estates at high elevations are much better suited. The value of a rubber estate at anything over 2000 feet elevation anywhere might well be taken at about one-third of that of a low-country estate, and would then perhaps be overestimated.

CHAPTER X

DIVISION OF ESTATES

ESTATES should be well divided into equal-sized blocks of, say, 50 acres each. This is generally found to be a convenient size for working. Blocks of 10 or 15 acres are too small, and blocks of 100 acres rather large. On the roadsides at each corner of the block a board should be erected on a post and should bear the number of the block in large, plain figures. An arrow should be painted on the board showing the direction in which the block runs. On some estates the age of the trees is indicated, and, if heavily supplied, the date at which the supplies were planted is also given. The number of the trees on the block is added on some Java estates.

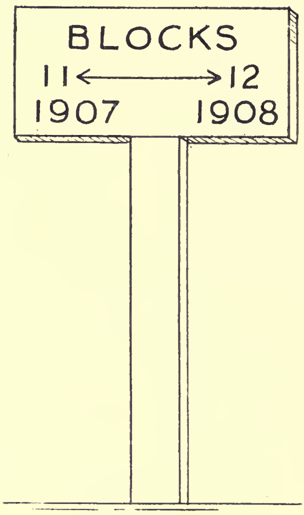

FIG. 11.

This system of marking out blocks is a very great convenience in estate-working. The manager can give clear instructions exactly where work for the day, such as weeding, cultivation, pruning or drain-digging, is to be done. Where new assistants are on an estate this saves much trouble. It also is a help to correct book-keeping, and it enables boards of directors at home to follow operations more easily. Reduced copies of a complete plan of the estate ought to be multiplied by lithography or other means. All assistants ought to have copies. Every month, along with the monthly reports, a copy should be dispatched to the board at home showing, in colours, areas in tapping, areas weeded during the month, and other details. Where new land is being opened the progress of extensions can be thus easily watched over. The blocks should be numbered consecutively right through the whole estate, not starting afresh in each division, or confusion will arise. As far as possible endeavour should be made to have trees of the same age in each block, ignoring supplies, of course. When an estate has not been properly divided off in its earlier stages this is difficult and shows the importance of early and proper demarcation.

CHAPTER XI

ROADS, BRIDGES AND DRAINS

WHEN the opening up of an estate is taken in hand, a manager naturally indicates on his rough sketch-plan where he proposes to have his main road through the estate. Later on the cross-section roads and paths are easily arranged for. It is always advisable that a main road to and through an estate be thoroughly well stoned, or cartage would be almost impossible during rainy weather. The sooner this work is taken in hand the better in all cases. Six dollars per acre is about the usual cost for 4-feet paths through an estate, but the cost of levelling and thoroughly well stoning a main road may well vary from £10 to £50 per mile. Where blasting has to be done on the road built up, and deep drains excavated alongside, increased outlays are unavoidable. In laying out a main road for heavy cartage endeavours should be made to avoid any steep gradients. It is better to make a considerable detour than to have such. Not only so, but in times of heavy rains steep portions of roads are very apt to be badly cut up by the rush of water. Bridges also have in many instances to be constructed, and form an item to be reckoned with. On one small estate broken up with narrow ravines, which was visited by the writer, there were fifteen bridges. Unless well and substantially erected, charges for the upkeep and repair of such are apt to recur with regrettable regularity.

For narrow ravines or wide drains which intersect the route of a main road no elaborate bridges are required. A few hardwood timber beams and planks are generally sufficient. For rivers and streams up to 35 feet in width iron girders can easily be laid across and the expense is not very great.

When rivers are from 50 to 150 feet wide, suspension bridges are usually found the cheapest, the most effective and the most serviceable. For one thing, there is no central pier in the midst of the river which would be apt to be knocked to pieces and swept away in times of flood by trees swept down the river. The cost of suspension bridges is not very great. The chief item of cost is usually their erection, as they require deep, wide and very secure foundations of cement for the blocks which have to bear the strain of the wire ropes. A good foundation is absolutely essential, and without this they cannot be built up on soft soils.

There are some estates which, from their nature, require few drains. These are estates planted upon land with gentle slopes, off which heavy rainfall naturally flows away. Their surface waters are readily got rid of, and but a few deep drains are required to collect the surface waters together, before they assume too great a volume, and conduct them peacefully to some outlet from the estate.

There are other estates, however, flat and low-lying, with which good and efficient drainage is a matter of life and death.

Estates with light sandy soils through which rain readily percolates are seldom in need of much drainage.

The water in the soil is lowered to the depth to which the drains are excavated, if the drains really carry away the water they receive, so that, instead of having constantly stagnant water in the soil, a movement of both water and air is established. The introduction of air which follows the water drawn off in drains stimulates the whole depth of the surface soil into activity. Plant-roots cannot possibly grow without oxygen from the air. Hence, in a water-logged soil, the roots are confined to shallow surface layers. Only after drainage can the roots go down so far as the circulation of air extends. When the air penetrates down, the bacteria start actively upon their work of supplying nitrogen to the roots of the trees.

The constant presence of an over-supply of water in the soil means death to the beneficial bacteria on which the roots of the trees depend for their nitrogen nourishment. It also means that the roots of the trees cannot breathe. With poorly-developed, badly-nourished roots, trees cannot maintain a healthy condition.

Not only is this the case, but water-logging encourages the activity of certain detrimental bacteria known as denitrifiers. Denitrification implies the reversal of the process of nitrification which brings fertility to the soil and involves the reduction of the nitrates even to nitrogen gas, which escapes

FIG. 12.—View of a Twenty-four-months Tree on Eastern Sumatra Rubber Estates, showing Fine Development of various series of Lateral Roots in a well-aerated Soil.

into the atmosphere. Hence, a serious loss of fertility to the soil not readily replaced. Drains are not meant to be receptacles for water, but means of getting rid of it. They can scarcely be too numerous. It is common for a planter to find that cutting an additional drain is one of the very best ways of getting rid of the disease of Fomes.

It is, therefore, absolutely essential at all costs to ensure that land is well drained. Many estates, more especially in Sumatra and the Straits Settlements, leave very much to be desired in this respect. The water-level in the drains is much too high. If the managers and the visiting agents of such estates realized how much the root-systems of the trees were restricted from this cause, and the constant loss of the fertility of the soil which was going on, they would not be content without securing better drainage.

The curious paradox is sometimes to be witnessed that the trees planted in a heavy, badly-drained, water-logged clay soil suffer from want of sufficient water supplies. The reason of this may not at first be apparent. It is due to the fact that in a water-logged soil the roots of the trees are necessarily confined to shallow surface-layers which the roots soon drain of all available moisture. At the same time the roots have the utmost difficulty in drawing further supplies from beneath, as water only percolates through clay with extreme slowness. As a consequence of this the trees suffer from want of moisture, there is poor root development and a generally-retarded condition of growth. Some object-lessons of this are to be seen on a few estates.

Of course it is wonderful what ill-usage Heveas will withstand, and under what bad conditions they can be induced to grow. Still, the enormous percentages of vacancies, repeated supplies, and badly-shaped and badly-grown trees to be found on ill-drained estates speak loudly to those who will listen.

In excavating drains care should be taken that the direction in which they run is in accordance with the natural fall of the land and the direction in which an outlet for surplus water can be secured. One would think this is sufficiently obvious to need no mention, but there have been cases where considerable sums of money have been spent on digging drains which afterwards were found to run in a wrong direction. Too great a slope in the drains will involve too rapid a rush of water and the sweeping away of soil. A fall of about one foot in twenty is about the limit.

The number of drains to be excavated and their distances apart depend entirely upon the nature of the soil to be drained. Heavy, water-retaining soils require far more drains than lighter soils do. The drains, of course, need not be all of the same depth. Main drains to carry away large volumes of water should be always deeper than cross-section drains. For a main drain a depth of from 6 to 10 feet is common, whereas cross-section drains are seldom more than 5 feet and often but 3 feet in depth.

The planning-out of drains ought to be done before the estate is planted so as not to interfere with and interrupt the passage to rows of trees, or, at all events, to do this as little as possible. Where drains do cross inconveniently they can—and should—be bridged over with slabs of cement. The cost is slight. Such small bridges are permanent. This method is a great improvement on the rotting and slippery logs in such general use in the Federated Malay States and Java. Many a dangerous fall is sustained through the use of these logs, and their use as bridges does not reflect credit on the management of the estates. To have a tidy estate and everything in good order should always be the endeavour of every manager. Details should not be despised.

It is of little use to excavate drains and allow them to become silted up. Drains should always be kept clear to the same depth if water is to run off freely. A good method to ensure this is to have cement slabs embedded in the bottom of the drains at convenient distances. When the bottom of the drains is seen to be level with the surface of the slabs, then the manager may know that the water will run off freely and the estate be well drained. If, however, the slabs are buried under soil, then they should be cleared and the bottom of the drains dug out again till they are level with the slabs. As it is often very difficult to find the position of these slabs when they are buried, a small slab of cement at the side of the bank just above the buried levels is a convenience. In hilly country, where there is a very heavy rainfall and the rush of waters into the drains is sometimes furious, it has occasionally been found necessary to cement both the bottom and the sides of the main drain, especially when there is a considerable fall to a lower level. This, although involving much expense, has been found to be a cheaper course than continually digging the drains clear.

The cost of drain-digging on low-lying, flat estates is generally taken at about £3 to £3, 10s. per acre. These costs are for ordinary drains, 3 feet deep, 3 feet wide. Roughly speaking, about one halfpenny per cubit foot excavated is what drain-digging to a reasonable depth costs. When specially deep drains are dug the cost is increased, as extra coolies have to be put on to convey the soil excavated from the ditch to the top of the bank and deposit it there. About five shillings per acre per annum should be sufficient to allow for the upkeep of drains on flat estates. Where there is wash of soil and drains are often filled up, costs are inevitably much increased.

CHAPTER XII

FELLING

WHEN a Government grant has been issued, or land acquired by purchase, the first thing to be done is usually to cut rentrices, or paths through the jungle, so as to form some idea of the varying conditions of the estate. Till this has been done the land remains hidden behind a veil of vegetation. How exclusive such a veil of tropical vegetation can be only those who have attempted to penetrate behind it can tell. Once fairly into the jungle, all sense of locality seems lost; and without blazing the trail as one proceeds one would soon be hopelessly lost. Many well-known planters have had a scare and come near to leaving their bones in the jungle. A native guide is very useful at such times, as the native seems to possess a sense of locality denied to the white man. A small compass should always be carried.

Some slight knowledge of the lie of the land having been acquired, temporary shelter for the manager and for part of the labour force becomes the first consideration. This having been erected, the next thing to set about is the felling of the jungle.

For this felling one need not usually have to await the arrival of contract labour. It is better, indeed, to have a fair clearance made before contract labour begins to arrive. The services of local natives are, therefore, usually secured. Whether these are Cingalese in Ceylon, Malays or Chinese in the Federated Malay States and Straits Settlements, or Battaks in Sumatra, the conditions are similar. The local labour force, while often not willing to engage in regular and long-continued task work, is quite willing to take up a contract for felling and burning the forest. Costs for felling and burning usually work out at about G.8 per acre in Sumatra, and the amount may be expressed in dollars to meet the costs in the Federated

FIG. 13.—Felling in Progress on a New Clearing.

Malay States, and would be still higher in Kelantan and Pahang. Suppose the manager intends to plant up 300 acres during the first year, and the same number of acres each succeeding year, he will thoroughly fell the first 300 in preparation for the good burn he always hopes for. It is very important so to arrange matters that one does not miss the dry season for a proper and, if need be, repeated burn.

Besides felling the first 300 acres in a thorough fashion, it is a wise thing to fell the heavy timber in those portions of jungle-land which it is intended to clear and burn next season. By felling the heavy timber only, the large tree trunks and roots get a much longer period to decay, and when, later on, the time comes to burn them, the wood will not be so green and full of sap, and so will burn more readily. All the smaller timber and brushwood in such areas is left uncut, so as to cover the ground and prevent lalang getting in and establishing itself.

When felling jungle trees, care should be taken to see that the trunks are cut through as close to the ground as possible, especially in the case of heavy timber.

Of course felling and burning still leaves the roots of the jungle trees in the soil, and many of these are of very large size and extend for considerable distances in all directions. These are a serious trouble when it comes to making regular lines for the holing and planting of the young Heveas. One has either to have vacancies or irregularities in the lines or get such roots out somehow. Undoubtedly the best plan is to get them out. This, however, is so expensive that many, if not most, planters prefer to leave most of the stumps and roots to the process of decay for a year or two before attacking them. Like growth, decay is comparatively swift in tropical climates. The monkey-jack is usually considered the best means of removing stumps and roots, but a few small dynamite cartridges might do the work more quickly, more effectively, and more cheaply. When one learns of the extent to which dynamite is employed in farming operations in North America, one wonders why it is that it is not in general use for plantation work. There is no such prompt, cheap and efficient method of removing stumps and breaking up the ground.

Whatever stumps and roots motives of economy may prompt a planter to leave in the soil for a time, there should be no half measures about immediately getting rid of all traces of the timber or roots of hardwood trees, such as the Johore, the Halebun, and others differently named or varying according to the various countries. The decaying timber and roots of such trees are the most fertile source of Fomes possible to imagine. It is only inviting certain disaster to leave them on or in the soil.

FIG. 14.—View showing Decaying Roots and Timber left on a Planted-up Estate.

The most careful inspection should be made, and all trees of this description so marked after felling and before burning that the stumps and roots will be easily recognized, even after they have been well charred by the flames. A little pile of stones beside each tree of this sort will help easy recognition. If no stones are available, as is generally the case in Sumatra, where stone is exceedingly scarce, an iron bar will serve the purpose. These trees usually grow in clumps of four or five and their roots infect a wide space. The writer has seen roots of these hardwood trees covered with white slime and Fomes. Whole rows of young trees fall over if they are not thoroughly sought out and the soil well limed. So much on this subject comes properly under the heading of felling, as prevention is better than cure, and further details should be sought later on in the chapters dealing with diseases and pests. There it will

FIG. 15.—Heavy Jungle Timber on New Clearing, Tanjong Malim Estate, attacked by White Ants.

also be seen what a serious part in the encouragement of white ants is played by these remnants of jungle trees.

When felling, a wise manager will select the best timber suitable for building purposes, and have it sawn up and removed before burning. There would be little wisdom in purchasing timber and paying for transport when one has a selection on the spot. Eventually, good timber always comes in useful, and the cost of having it sawn into suitable beams and planks, and stacked for seasoning, is not great.

CHAPTER XIII

BURNING

THE longer the timber has been felled before burning the better the prospect of obtaining a successful burn. Naturally, heavy, green timber full of sap does not burn well, whereas, if cut for a reasonable time beforehand, the flames, even if they do not thoroughly consume large trunks, at least burn well into the heavy logs, and render them more subject to decay, more easily handled, and more easily broken up, than if they are merely slightly charred on the outside. Slothful management is expensive management.

When a manager proposes to burn timber it is his duty to take precautions against the fire spreading further than he intended. If another estate closely adjoins his plantation he must give timeous notice to the manager of the next estate of the exact date and hour at which he proposes to commence work. Having received such notice the manager of the neighbouring estate will post a gang of coolies to watch the boundaries and be prepared to beat out any flames which might show a tendency to spread. It is, of course, also incumbent on the manager who proposes to start burning that he should have a gang of his own coolies on his own boundary to take all precautions against the spreading of the flames.

Even if only Government jungle is on the boundaries it is necessary to take these precautions. The writer is the director of a plantation in the Federated Malay States, the manager of which on one occasion received due notice that his neighbour proposed to burn on a certain date. Gangs of coolies were duly posted as usual, and the burning was in progress, when suddenly a fierce wind sprang up and carried the flames and small pieces of burning timber into the plantation with which the writer is connected. Despite all the efforts of the managers and their coolies, twenty acres of young rubber, about nine months old, were burnt out. As the neighbouring manager had given due notice, and taken every reasonable precaution, no claim was made. It will, however, be readily understood that, had he been neglectful, and had not given due notice and taken proper precautions, the matter might have had serious consequences for him.

It is, unfortunately, a very common occurrence to see

FIG. 16.—Burning in Progress on a New Clearing.

ground which is planted up with young rubber littered with the decaying trunks of jungle trees. Where, as in Sumatra, many of these jungle trees have been of enormous size, it is almost impossible to remove the heavy trunks. These are often right in the planting lines, and roots and stumps remaining in the ground present serious obstacles to their being rolled out of the way. Stacking such heavy timber is a most difficult task, and yet, if stacking is not done, weeding expenses are much higher, as coolies cannot easily chankol soil covered with, or sheltered by, heavy timber. The importance of a good burn at the proper season, when the weather has been hot and dry for some time, is thus obvious.

Failing to obtain this, from whatever cause, the timber lying on the ground should be got rid of as soon as possible in one way or another. The process of decay, always so active in tropical climates, helps very much, but needs assistance if the land is to be cleared within a reasonable time, if weeding expenses are to be kept low, and if the ravages of Fomes and Diplodia are to be kept within bounds. I have known of nearly 40 per cent. of the trees on a planted area being attacked by Fomes, owing to timber being left lying to decay and roots left rotting in the ground; a confirmation of the old saying, the less hurry, the more speed.

Sometimes the fault is not with the plantation manager so much as with the board of directors. Peremptory instructions are sent out that 500 or 1000 acres must be planted up in the course of twelve months. It may be impossible to do this properly, but it has to be done somehow. The burning is done in a hurry, perhaps not at the best season of the year, and, at any rate, while all the heavy timber is still green and full of sap. In consequence, after the burn is over, it is found that only the brushwood and smaller timber have been consumed by the flames. The heavy timber trunks still remain intact, or almost intact.

Under such circumstances a good manager will take steps to get rid of these trunks of timber during the first dry season. There are ways in which this should be done, and others in which it should not be attempted. During a recent visit to the Acheen district of Northern Sumatra the writer saw a plantation which was planted up with rubber trees from eighteen months to two years old. The timber was being burnt off this estate, and no precautions were taken to shelter the young trees or ascertain the direction in which the wind was blowing, so that the trees might not be scorched by flames or hot air. The consequence was that widespread devastation was taking place. The illustration given herewith indicates the method which should be adopted under such circumstances.

The planter who employed this method of clearing his plantation of timber informed me that, on the first occasion, he employed corrugated galvanized iron sheets 10 feet high.

He found that these sheets were not of sufficient height to give full protection to the young rubber trees, the upper foliage of

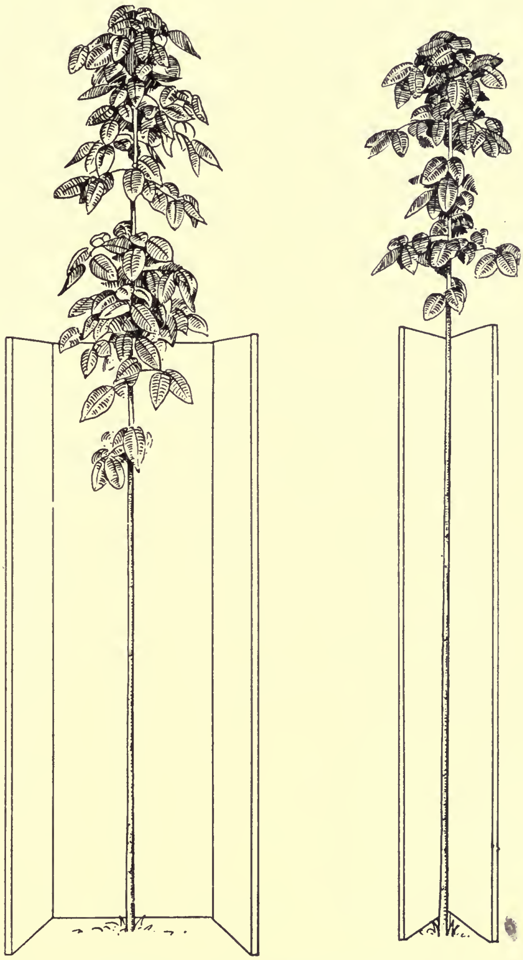

FIG. 17.—Illustrations of Protective Tree Shields used when burning lying Timber.

which was much scorched by the heat. He accordingly increased the height of the corrugated iron sheets to 12 feet. The protective cases of sheet-iron were moved a little further away from the trees, to which they had formerly been too closely placed, and thereafter it was found that the young trees escaped all damage.

The other method, as previously explained, is of a very similar character, the difference consisting in the fact that, instead of using three large sheets of galvanized iron, which takes some labour to remove from place to place, two planks of green unseasoned timber are employed. These planks are usually 12 to 14 feet in length, and from 1 to 1½ feet in width. They are placed together in front of the tree at an obtuse angle, in the manner indicated in the illustrations given above.

It will be obvious that no great area can be burnt off at a time by either of these methods, as the number of galvanized sheets required in the one case, and of planks in the other, will be too great to be conveniently provided. From half an acre to one acre at a time is as much as can be conveniently taken in hand. Still, the work is well worth the trouble. No planter worthy of the name can rest content till his planted areas are clear of timber and roots. An untidy plantation is offensive to the eye of any true planter. Even if a little outlay is incurred it will be found true economy, in the end, to get rid of such fertile sources of disease as decaying roots and timber.

The cost of burning off lying timber, when there is a fair amount of it, works out, in actual practice in the Federated Malay States, at $12 to $13 per acre. When roots have to be extracted by jacks and burned, the cost of getting rid of these has varied from $25 to $40 per acre. With a few dynamite cartridges the work of getting rid of the largest roots could be done at more moderate cost and at the same time be much better done. The small roots should be dug out and burned, and not the large ones only, if white ants and disease are to be kept under.

CHAPTER XIV

LALANG LAND

THE difficulty of getting rid of lalang was formerly esteemed so great that most planters avoided a stretch of good country with lalang, preferring to clear and plant up hilly land under jungle rather than attempt to clear the best lay of flat country of the lalang growing luxuriantly thereon. Of recent years quite a change of sentiment has set in.

Experience has shown that rubber planted in lalang land is almost entirely free from the Fomes which often works such disaster on freshly-cleared jungle lands. White ants, too, do not infest lalang land, as there is no decayed timber on which they can feed.

If the land is flat it can often be cleared of lalang in an economical manner by means of repeated ploughings, and the flat land has the great additional merit of not being subject to wash of surface soil. Leading visiting agents in the East who have superintended the planting-up of thousands of acres of rubber have informed me that if they were choosing a piece of land for themselves to plant up with rubber it would be flat lalang land. Personally, I know of no land so good for planting up with rubber as a fair extent of flat lalang land.

Once lalang has been entirely, or nearly entirely, extirpated, one coolie ought to be able to keep 3 acres in a good, clean-weeded condition. Thus, for the purposes of weeding 900 acres, 300 coolies would be a fair allowance.

Next in my estimation would come land formerly planted with tobacco. Here, as a rule, there is very little heavy jungle, and, consequently, the planter has but little trouble with Fomes. With a piece of land of this description one also reaps the benefit of the drains already excavated by the former tobacco planter, and also finds that the estate has been well roaded throughout. These are no small advantages.

Land formerly planted in sugar is to be found in the Straits Settlements. It is always flat land. Here, also, drains have been dug and roads made throughout the estates. In such areas like those mentioned above there is very little Fomes indeed to trouble the planter.

The land to be avoided, above all, is usually found in long-settled districts, where the security of good government has tempted a large population to settle there and to engage in agricultural pursuits. Such land is to be found in Malacca, in the extreme south of Johore, and in the island of Singapore. There fields have been heavily cropped for more than a hundred years with tapioca, gambier and pineapples. Three cultivations more exhausting to the soil it would be scarcely possible to find.

The Chinese agriculturist takes everything possible out of the soil but never thinks of restoring anything. In consequence, rubber planted upon such areas is always extremely backward for its age. The poorest rubber for its age which the writer has ever seen was planted on such estates in the south of Johore, and in the island of Singapore. There Hevea trees three and a half years of age looked poor growth for eighteen months.

The only land at all comparable with these for poor growth is to be found in the old, abandoned coffee-estates in Java. There also the land is often impoverished, apparently to the last degree; but the natural fertility of the soil of Java is so great that it usually can be worked up again in the course of two or three years by repeated chankollings till it resumes much of its former fertility.

Fig. 18.—Chankolling out Lalang.

CHAPTER XV

NURSERIES

WHILE the operations of felling and burning are in progress, steps ought to be taken at the earliest possible moment for the establishment of nurseries. It is always advisable to buy the Hevea seeds for these nurseries from some plantation with a good name for the condition of its rubber, and one which has trees of mature age.

Seeds should never be taken from a plantation which is known to have large areas of trees badly afflicted with warty growths or burrs under their bark. There are such. Seeds should not be purchased from plantations whose soil is poor and impoverished. There are such also, as readers will have gathered from previous remarks. Even in the case of good old estates, of former high reputation, when one hears of large numbers of acres of mature trees being rested, of bad bark-renewal, and of programmes of extensive thinning-out, it is better to go elsewhere for seeds, as the trees there are devoid of most of their vitality, and the seeds from them have a poor prospect of developing into vigorous young trees later on.

The heaviest seeds are not only the most productive, but generally the most vigorous and enduring. Care should therefore be taken to select large seeds, and to reject small, shrunken and misshapen seeds. Those interested in practical forestry have found that the largest seeds produce the strongest and best growing trees. The same rule should, therefore, be followed by rubber planters.

Seeds should always be purchased with a guarantee of 80 per cent. germination. Seeds purchased with such a guarantee cost a little more per thousand, but that is a small matter compared with the corresponding advantages. One may fairly be certain that the vendor of seeds under a guarantee will see that they are freshly gathered, promptly packed, and promptly dispatched. Every planter knows that Hevea seeds lose their vitality so quickly that a few days' detention in transit, or delay in planting them up when they arrive, is a most serious matter.

In the case of a Java plantation which some time ago received a consignment of Hevea seeds from Sumatra, there was delay in landing, the ship having been put into quarantine on account of cholera at a port where it had touched. The consequence was that the unloading was delayed for about ten days. This delay seriously affected the vitality of the seeds, and when they were planted barely 5 per cent. germinated. Such cases are not rare. It will thus be seen that delays have serious effects on the vitality of the seeds. All other things being equal, the nearer the plantation sending the seeds to that ordering them, the better when the seeds have been received.

Different planters pursue different methods. Some very good and careful planters spread the seeds out and water them well, and only select for planting those which germinate within four or five days. All others are rejected, it being assumed that their vitality is weak. The seeds which have germinated are then either promptly planted-out in nurseries, or in the fields as seed at stake.

Other planters argue that this is an unnecessary waste of time and expense, and they plant the seeds out directly into the nurseries, or into the fields as seed at stake.

When one plants out directly into the fields everything must be ready. The ground must have been all cleared and well dug over, so that the roots of the seedlings may have loose soil in which to spread. It is not necessary to dig holes under such circumstances. The seeds should only be planted about one inch beneath the surface of the soil, so that the stem and leaves may quickly reach the light. Deep planting would be injurious. Two or even three seeds are usually planted together and the most promising plant is allowed to remain.

Nurseries should always be established on virgin soil carefully dug over and, of course, without any roots or stumps left in the soil. As before stated seeds should not be planted deeply in the soil. Just a covering of soil is sufficient.

When lining out nurseries with string a distance of 1 foot by 1 foot is usually thought ample by most planters. No

FIG. 19.—Nursery lined out and seeds deposited, ready for planting.

doubt, if a planter was absolutely certain of being able to promptly plant out all the young plants, these distances would, in ordinary circumstances, be sufficient, as, when the young plants were very tender, each one would help to shade the others. It is, however, a very common thing in all parts of the East to find seedlings which have been left in the nurseries for twelve, eighteen or twenty-four months, or even longer, and in such cases the extremely close planting is bound to have had injurious effects on the health of the young plants. When

FIG. 20.—Nursery, with Shade removed before Planting-out.

such long-delayed seedlings are taken out of the nursery the roots suffer severely.

The tender seedlings should be protected from the strong glare of the sun by thatched coverings of attaps or bamboo matting. Later on, when the seedlings have established themselves, these coverings should be gradually removed, so that the young plants may be hardened and thus enabled to withstand the glare and heat of the tropical sunshine. Unless this is attended to they are apt to wither and require heavy supplying.

It is, of course, necessary to water the seedling plants well each evening. For this reason, no matter how long the beds may be, they should not be more than about 4 feet wide, with passages between, through which the coolies can walk up and down to water the seedlings.

Many planters favour planting the seeds in the nurseries each in separate baskets, so as to have basket plants for planting-out, that is, plants with all the soil round the tender rootlets contained in the basket, and planted-out undisturbed and uninjured in the fields. These baskets can, as a rule, be readily procured from the local native populations. They are of various sizes and can be made according to the requirements of the planter. If the baskets are not of fair depth the tap-roots of the young plants will, within three or four months, have reached the bottom of the baskets, and finding the tough fibres of which the baskets are composed an obstacle which they are unable to penetrate, the tap-roots become twisted and bent, and the young plants therefore unsuitable for planting-out. It is therefore obviously necessary that whatever advantages basket plants offer they must be promptly planted-out or they will become unserviceable. In such circumstances planters sometimes tear open the bottoms of the baskets and place them upon soft, loose soil, into which the tap-roots penetrate. Such plants are, however, very troublesome to plant-out later, as the utmost care has to be exercised to prevent tap-roots being badly bent or twisted. It is therefore plainly desirable that, if basket-plants are to be used, the baskets should be as deep as possible. In all cases the bottoms of the baskets must be torn or cut well open when the plants are being put out in the fields.

A method frequently employed in Java is to use what are called poeterans instead of baskets. These poeterans, or little pots, are composed of a mixture of cattle manure and clay. They are well baked in the sun so as to become hard, but not too hard to dissolve later on when planted-out in the open fields and exposed to the moisture of the soil. Trees planted in this way grow remarkably well. For example, on the well-known Limburg estate in East Java, one-year-old trees which had been planted in poeterans were quite equal to two-year-old trees planted in other parts of the estate by the ordinary method.

FIG. 21.—Seedling Plants in Extra Large Baskets.

The object of establishing young plants in nurseries before planting-out is, of course, principally to give them a good start in life, and to render them less liable to attack from their many

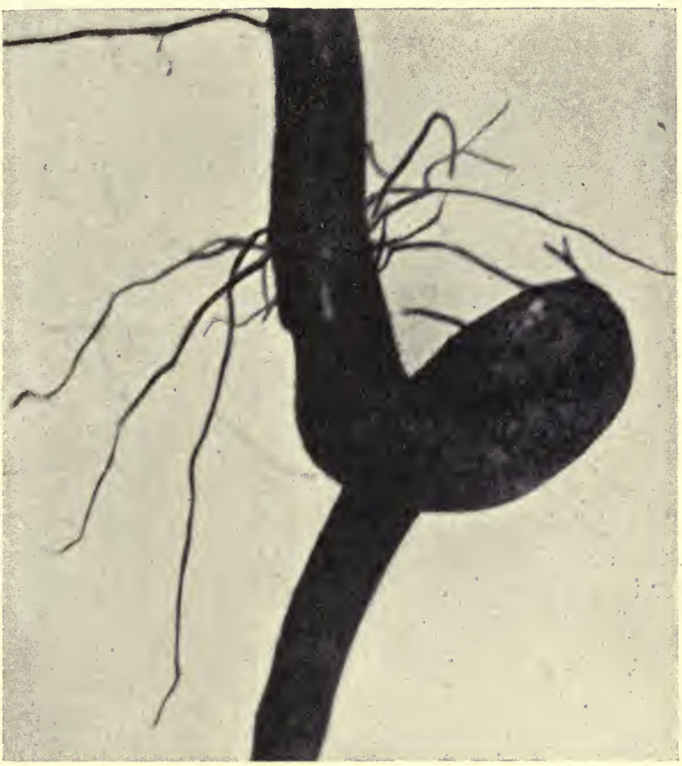

FIG. 22.—Illustration showing Twisted Root of Rubber Seedling.

animal and insect enemies. Even if there were not these reasons it is obvious that time is being saved when young plants are growing at the same time as the operations of felling, burning, lining and holing are proceeding.

CHAPTER XVI

PLANTING-OUT

WHEN the time comes for planting-out the seedlings from the nurseries into the open fields, if they have not been grown in baskets or poeterans, one of two methods is generally followed. Many planters, especially in Sumatra, use zinc cylinders about 5 inches in diameter, which they pass over the top of the seedlings and press down into the soil, so as to lift all the earth attached to the roots away with the young plant. These are then conveyed to the open fields, and, the cylinders being split at one side, it is a simple matter to slightly open them and let the young plants, with the soil attached, gently rest in the holes previously prepared.

When it is intended to use what is called stumps for planting-out, the seedlings are generally allowed to remain somewhat longer in the nurseries. Six months is a convenient age, but, on occasion, plants even two and a half years old are used for stumps. This, of course, is too long a period for seedlings to remain in a nursery and is not recommended. When a supply of stumps is required the seedlings are simply pulled out by hand from the soil of the nurseries. Poorly-developed plants, and all with twisted roots, should always be rejected. To make a stump, the upper part of the stem of the young plant with all foliage is cut away, and the tap-root, if too long or twisted at the end, is also cut short.

It pays well to very carefully select plants from the nurseries for planting-out. A rejection of 25 per cent. of young plants which are poorly-grown or have twisted roots is quite a small percentage in actual working. As a matter of fact it would be profitable only to select 25 per cent. or 33 per cent. of the very best seedlings and thus ensure fine, vigorous young plants, which later would develop into splendid trees. This is better than including the fair to middling seedlings in those selected

FIG. 23.—Illustration showing a Ten-months Seedling Stumped for Planting-out.

for planting-out, as is nearly always done. Seeds are not expensive and the cost of the establishment and upkeep of nurseries is so very moderate a sum that it would pay well to establish large and numerous nurseries and select more thoroughly. The more rapid and altogether better average growth of the young trees thus secured would repay any slight additional expense many times over.

This cutting-short of the stems and roots is, of course, a severe shock to the plant, but, given favourable weather, the stump soon establishes itself in the soil and puts out fresh foliage. The bark of a stump is, of course, thicker, and the stem not so juicy as that of a seedling which has been planted at stake. It is therefore not so tempting a tit-bit for porcupines, rats, deer, wild pigs and other animals, or for such insects as the mole-cricket. When one states that it is not so tempting to these creatures one does not mean that it is immune from attack. This is very far from being the case; but still it is rare that the stumps get eaten away in the wholesale fashion that seedlings sometimes do.

There is no doubt that while, as pointed out, stumps offer certain advantages as against seedlings, stumping is an operation of a very drastic nature and very severe upon the young plants. In stumping the green foliage is cut away and the tap-root and small lateral roots trimmed down. There is thus left only a thin rod. The shock to the plant naturally prevents it putting on almost any growth in height and in girth until, if successful, it has managed to establish itself in the soil with fresh roots and has developed fresh foliage. A seed, if planted out in an adjoining field at the same time as six-months-old stumps are planted in the other, will soon equal them in growth and be a better-shaped plant.

The age of rubber should always be calculated from the time it is planted out. Thus, if six-months-old stumps have been planted out for a month, the age of the rubber should be considered as one month. This is the method of calculating age now generally adopted.

Whether a rubber tree developed from a stump will have the same longevity as a tree grown from seed yet remains to be seen. On the face of it, it might appear rather doubtful. A man who had a leg cut off when he was a boy would not be considered so good a life by an insurance company as another man of similar physique in possession of all his members. The removal of the leg, however skilfully performed, would reduce the first man's store of vitality very considerably. His constitution would be weakened and he would be more liable, throughout life, to succumb to an attack from any disease which might affect him.

So a tree developed from a stump which has been torn from the soil and had its foliage and its roots drastically pruned one would think must suffer from a reduced vitality throughout its lifetime. It can grow a new head of foliage and a new footing of roots, and possibly could do this twice over, but would, in that case, show unmistakably how it had suffered. Some contend, however, that plants and trees, which undoubtedly frequently benefit by pruning, must be judged from quite a different standpoint, and this, within limits, is correct.

Before a planter has his seeds, seedlings or stumps ready for planting-out, it is necessary to have the ground "lined" in advance. "Lining" means marking out the future ground with cord, so as to ensure that the trees of the future plantation will be in straight lines and at regular distances from each other. Few things are more offensive to the eye of a fastidious planter than irregular lines, with trees every here and there out of their places. The lines should always be so planned that the avenues between the trees run east and west and not north and south. This is important, as it gives all the trees a better opportunity of securing a fair share of the morning and afternoon sunshine than if they were planted in avenues running north and south.

Anyone who takes the trouble to examine plantations with lines running north and south, and compares them with those having avenues running east and west, will see for himself how much darker and gloomier are the former in comparison with the latter. Sunlight is so very important for the growth of the foliage, on whose luxuriant existence depends the welfare of the trees, that one cannot afford to neglect any opportunity of securing as much of it as possible for the sides as well as the tops of the trees. Gloom and darkness invariably indicate early decay.

When seeds are planted-out at stake it is not necessary to

FIG. 24.—A Six-months Stump.

dig holes for them. The chankolling, which will of necessity have been done to clear the ground of lalang, and otherwise prepare it, even if the soil has been virgin jungle, will have sufficiently loosened the soil. All that is therefore necessary is carefully to deposit the seeds about 2 to 3 inches beneath the surface of the soil, regularly in line and at the distances decided upon, the exact situation of which should be carefully marked out with small stakes stuck into the ground.

In the cases of basket-plants or poeterans, and of stumps, it is necessary to have holes dug in advance. These holes should be dug at least three or four weeks in advance of planting-out, so that the soil may become sweetened by the sunlight and air. This sweetening of sub-soil is very important and cannot be too well attended to. Next to prolonged and unseasonable droughts the chief cause of the failure of seedlings and stumps is the sourness of sub-soils, and for this sourness light and air are the great and almost only cure.

One effect of leaving holes open for three weeks or longer is that the soil beneath becomes aerated and the bacteria actively colonize the deeper soil below the roots of the young plants and greatly add to the fertility of the soil.

The usual depth to which holes are dug is 2½ feet, and the width and breadth are usually 2½ feet also. As exposure of sub-soil to light and air is the best means of sweetening the sub-soils, it is evident that for the sanitation of the young plants the width and breadth of the holes cannot be too great. Digging a wide and broad hole gives an opportunity to detect and remove any decaying roots. It also so loosens the soil all round the young plant that the surface rootlets expand more quickly and more widely than they would otherwise do, and this greatly assists vigorous growth in the young trees.

On an estate in North Sumatra the manager caused all the holes for young plants or stumps on a certain considerable area to be dug 6 feet square by 2 feet deep. The manager reports that the growth of the young trees on this area has been surprisingly good and has quite exceeded expectations.

If it is found in the interval between the time the holes are dug and the time for planting-out that the soil at the bottom of the holes has become hardened under the influences of tropical sunlight, it will not take more than a minute for a coolie to loosen the sub-soil at the bottom of the holes with a fork. When planting-out the stumps two men should always work together at the task. One coolie should be employed in filling up the holes and the other in holding the stumps and in seeing that they are set straight, and the roots not in any way twisted.

In filling up the holes only fresh surface soil scraped from the surface round about should be employed, because the surface soil is much the most fertile. The reason of this is that soil near the surface is full of bacteria. The deeper one digs into the soil beneath the surface the fewer are the bacteria present in the soil. Below a certain depth from the surface no bacteria are found to be present.

On very many estates there are certain areas on which it is found to be exceedingly difficult to establish seedlings or stumps. The young plants sicken and die out, and these areas have to be planted and replanted or very heavily supplied again and again. Digging deep and wide holes, and leaving the soil which has been excavated exposed to sunlight for several weeks, is a great help in such cases. The soil in such instances is, no doubt, from some cause sour and infested with maleficent bacteria, and the sunlight kills them out so that the soil is ready for fresh and vigorous colonies of beneficent bacteria.

It is well known to farmers in England and elsewhere that by burning soil in kilns it afterwards becomes exceedingly fertile. The burning splits up particles of mineral matter and renders available to fresh colonies of bacteria abundant food supplies, while it destroys organisms that feed on bacteria.

A little unslaked lime spread over the soil and powdered into the holes corrects soil sourness and assists the beneficent bacteria to recover the soil into a good state. In cases of low-lying land which has been swampy, lime *is* especially necessary. As a well-known planter is fond of repeating about such areas: lime and time do the business.

If two men working together do the planting and filling up of fifty holes in a day, this is good work. It is much more important to have the planting well done than to have twenty or thirty additional holes filled up per day. The soil filled into the holes should be well trampled down by the coolies, who should be careful to see that the roots of the stumps are well

FIG. 25.—Coolies digging Holes for Planting-out.

packed, and that no vacant spaces are left for water to lodge in and cause rot, or which might allow the young plant to get out of its erect position.

It is almost unnecessary to state that it is useless to plant-out during a dry season, or just before it sets in. Of course seasons are uncertain. Rains sometimes start and do not continue as they ought, and so much of a planter's labour may be thrown away. All that can reasonably be required of any planter is that he should take all proper precautions.

When the stumps or seedlings have been planted-out they should be inspected weekly, and any plants which do not show signs of thriving should be pulled up. Those pulled up should be again stuck in the soil with their roots up in the air. They are thus easily detected by the coolies who go round to do the supplying. Vacancies should be always very promptly supplied, in order to keep the growth of the young trees regular. This is important, but is neglected by some managers.

CHAPTER XVII

PRUNING

GENERALLY speaking there should be as little cutting away of branches as possible consistent with the development of a good, straight stem on the young tree, so as to develop ample and uninterrupted space for tapping operations. Whatever pruning has to be done should be done before the trees are two years of age.

There is, unquestionably, too much pruning away of branches on nearly all estates. Especially is this so in the case of the lower branches about 10 or 12 feet from the ground. These, although at first they may appear weakly and inclined to bend down, should not be cut away quite close to the stem. They should be pruned about a yard from the stem and left to develop into strong branches bearing good foliage, as they generally do. The best trees have well-developed lower boughs. It is a pity when a tree has to depend solely upon a mass of high foliage as the principal means of manufacture of its food supplies. The illustration given herewith shows a case of such an improper method of pruning.

At one time what is called "thumb-nail pruning" was rather popular among planters. This consisted in nipping off the top-shoot of the young tree when it was about twelve months old. The effect of this was that young trees which were naturally inclined to grow tall and spindly greatly increased in girth and developed a heavy system of branches all round the stem.

Unfortunately the too-frequent effect was that the slender stems of the young trees were not able to support a heavy development of branches. Very often, especially during strong winds, the stems of the young trees snapped across or the trees were blown over. So much was this found to be the

FIG. 26.—Pruning a useful high Branch too close to Stem.

case that the system fell into disfavour and has generally been abandoned.

A somewhat similar system, but delayed to a more advanced age of the trees, has been tried on some estates. On Blankahan Estate, Sumatra, belonging to the Langkat Sumatra Rubber Company, Ltd., there is an area where several hundred tall trees, two and a half years of age, were topped by sawing off the upper portion of the stems about 15 feet from the ground.

FIG. 27.—Trees broken by Storm and sawn across the Stems.

These trees subsequently developed a fine system of branches all round and grew splendid trunks. Had they not been cut they would always have been poor, spindly trees. Several planters have strongly urged that such branches must be brittle at the point where they unite with the trunk of the tree. This is certainly not the case with the trees on the Blankahan Estate, which appear to have greatly benefited by their severe treatment and have increased their girth considerably. Still, one would hesitate to recommend such a system for general application without taking great precautions.

Wherever double stems develop in young trees one of these stems should be removed as early as possible so that one thick stem alone should be developed. Forked trees are very apt to split during gales of wind. When a forked tree splits in this way, as a rule nothing remains to be done but to cut the tree out, whereas in the case of an ordinary tree broken across, once the stem is smoothly sawn across and the cut well tarred over the trunk again puts out branches.

As already stated, any pruning of branches should be done while the trees are quite young. It is then that any long, trailing branches, or branches making the tree unshapely or one-sided, should be removed. Then also should be cut away any branches growing from the stem too low down. As a rule planters cut away lower branches close to the stem too freely. Trimming of the ends of these branches would often suffice and the branches would later develop into fine spreading boughs. All cuts should be promptly and carefully tarred over.

Trees which have been broken by heavy gales should be sawn across and well tarred over. Care should be taken that no cracks or crevices exist below the place where the trunk of the tree is sawn off. It is better to saw across low down than to have any such crevices, which would otherwise simply serve as a lodging-place for the ubiquitous spores of fungi or for water lodging in the crevices to cause rapid decay. On one well-known estate in the Klang district this precaution had been neglected, and many trees which had been broken across had to be sawn across afresh, a very severe tax on the vitality of the trees.

FIG. 28.—An instance of a Double-stemmed Tree.

CHAPTER XVIII

PLANTING DISTANCES

	10	12	14	15	16	17	18	20	21	22	24	30	32	36	40
10	435	363	311	290	272	256	242	217	207	198	181	145	136	124	108
12	363	302	259	242	226	213	201	181	173	165	151	121	113	103	90
14	311	259	222	207	194	186	172	155	148	141	129	103	97	88	79
15	290	242	207	193	181	170	161	145	138	132	118	96	90	82	72
16	272	226	194	181	170	160	151	136	129	123	113	90	85	77	68
17	256	213	186	170	160	150	142	128	122	116	106	85	80	73	64
18	242	201	172	161	151	142	134	121	115	110	100	80	75	69	60
20	217	181	155	145	136	128	121	108	103	99	90	72	68	62	54
21	207	173	148	138	129	122	115	103	98	94	86	69	64	59	51
22	198	165	141	132	123	116	110	99	94	90	82	66	61	56	49
24	181	151	129	118	113	106	100	90	86	82	75	60	56	51	45
30	145	121	103	96	90	85	80	72	69	66	60	48	45	41	36
32	136	113	97	90	85	80	75	68	64	61	56	45	42	38	34
36	124	103	88	82	77	73	69	62	59	56	51	41	38	35	31
40	108	90	79	72	68	64	60	54	51	49	45	36	34	31	27

THE table at the head of this chapter will be found serviceable as a ready reckoner in calculating the number of trees per acre at any of the given distances from each other. Thus, for example, 14 feet by 14 feet—a very common distance in the Federated Malay States—will be found to give 222 trees to the acre, while 20 feet by 20 feet—a distance which has recently come into favour—gives 108 trees to the acre.

To find any numbers not included in the table, divide the square of the distance apart in feet the trees are desired into 43,560—the result indicates the number of trees contained in an acre.

Up till now there has been no general consensus of opinion as to what are the proper distances at which Heveas should be planted-out. Every planter has done what seemed good in his own eyes. Ten feet by 10 feet, 12 feet by 12 feet, and 14 feet by 14 feet are now generally condemned by most planters as too close planting. Yet many of the leading plantations in the Federated Malay States have large areas planted at these distances. On one very large estate in the Federated Malay States which has been planting within the last three years the great bulk of the planting has been done at this close distance.

Nearly all the older estates are planted up at a great variety of distances. The planters having, in the beginning, no certain rule to follow, tried something of almost everything, so that there are quite a number of estates on which one can find trees planted 10 feet by 10 feet, 12 feet by 12 feet, 14 feet by 14 feet, 17 feet by 17 feet, 12 feet by 24 feet, and so on, six to ten different varieties of distances existing on the same estate. As a rule, however, planters are now practically agreed in condemning any closer distances than 17 feet by 17 feet or 12 feet by 24 feet—distances of which there are many examples to be seen. Recently there have been stout advocates for wider planting, and 20 feet by 20 feet is the distance at which very many thousand acres of new clearings have been planted up in Sumatra.

When considering planting distances, what appears to be a paradox should be borne in mind, namely, the poorer the soil the more trees to the acre it can support; the richer the soil the fewer trees to the acre it can maintain. The reason for this is that on poor soil the trees grow more slowly, the roots do not extend to such wide distances, and the foliage has a smaller spread.

On broken, hilly country, such as is common in Ceylon, Borneo and Southern India, trees can stand closer planting to the acre than on the flat lands of the east coast of Sumatra, Province Wellesley and the Federated Malay States, although, as a matter of fact, they really approach closer together than

FIG. 29.—An instance of Close-planting on an F. M. S. Estate.

they do on flat land. This is on account of the fact that on broken, hilly country successive rows of trees occupy higher elevations, and light and air get in to an extent impossible at the same distances on flat lands, and there is less interference of the roots of one tree with another.

Except on very hilly land or very poor soils all such close distances as even 20 feet by 20 feet, and any distance or combination of distances under that, is to be condemned. The spread of the foliage of Hevea trees of various ages in the Federated Malay States, in fair circumstances, is approximately as follows:—

Age of Trees	Total spread of branches in diameter
4-year-old trees	16 feet
5 ,, ,,	20 ,,
6 ,, ,,	25 ,,
8 ,, ,,	30 ,,
10 ,, ,,	35 ,,
12 ,, ,,	40 ,,

In Sumatra perhaps a foot less diameter may be allowed for each respective year, and in Ceylon at least a foot less per annum than in Sumatra.

The consequence is that if trees in the Federated Malay States have been planted at distances of 14 feet by 14 feet, by the time the trees are four years of age the branches will have grown together so closely that the higher branches will so densely overshadow the lower branches that no foliage can possibly grow on them. Should the trees have been planted at a distance of 20 feet by 20 feet, by the time they arrive at the age of five years the branches will have met together. By the time that they are seven or eight years old the lower branches will be so overshadowed by upper branches that they will be destitute of foliage, and having thus no function to perform will be found to be rotting off the trees.

One thing which at the outset strikes—or should strike—any observant visitor to such plantations is the miserably-circumscribed spread of the roots of the trees and their very meagre thicknesses. This is a very serious matter for the trees. When the roots of the trees can draw their supplies of moisture and of food in solution only from very limited areas, they cannot grow so quickly, they cannot withstand droughts so well, and they cannot have the vitality which they would possess if the roots had an area three or four times as great to draw upon for the necessary supplies. Close planting thus infallibly means poor root-systems, and all the consequences which follow, for the area which the roots of the one tree might seek to occupy is, it soon finds, already occupied by the roots of other trees which are draining the soil severely and which, in any event, crowd the narrow spaces available.

It must also be remembered that as trees grow older their girth increases. The bark area, which must necessarily be renewed after tapping, is much greater than was the case in earlier stages. If the trees have been planted at sufficient distances the spread of the branches and, consequently, of the foliage, will have greatly increased, and the trees will be in an equally good or a better position to renew all bark taken off than formerly was the case.

On the other hand, if the trees have been closely planted at the distances general in the Federated Malay States and the Straits, namely, 14 feet by 14 feet, 17 feet by 17 feet, or 12 feet by 24 feet, their spread of foliage at the age of eight, ten or twelve years of age will be much less than it was at the age of five or six years. The trees will have a far more severe task laid upon them to perform and be in a much worse position to accomplish it. Bark-renewal will therefore be much slower. The attack on the vitality of the trees will eat into their reserves of strength. The proportion of trees attacked by disease will increase. The position of closely-planted estates, considered as a permanent investment, is thus a very doubtful one.

It is most astonishing that more planters do not generally recognize what is every day before their eyes. Anyone who cares to look at very many of the estates in the Federated Malay States with trees six years of age or older will see a dismal sight. There one can behold gloomy aisles of trees into which the sunlight never penetrates. High overhead the uppermost boughs of the various trees contest with each other for a little air and sunlight. Below are to be seen the evidences of death and decay. As no foliage can grow on the lower branches, owing to the perennial gloom, these decay and fall off. Each year, as the uppermost boughs climb ever higher, another circle of the lower branches shows signs of decay and eventually shares the fate of its predecessors.

Any mycologist will inform planters that decaying branches lying on the ground are fruitful sources of Diplodia. Yet on most of such plantations portions of these decayed branches continually crack under one's feet as one walks over the estate.

In Sumatra things are very seldom so bad, and then generally only on small areas of the estates. The reason is, in the first place, the oldest rubber there was nearly always formerly interplanted with rows of Liberian coffee, which is a fairly large bush and took up a good deal of space. Now that the coffee has been cut out between the rubber trees, distances of 24 feet by 24 feet and 30 feet by 30 feet are not uncommon. In the second place, the great majority of estates are planted at distances of 20 feet by 20 feet, with trees which are yet young, say five years old and under, and the evil effects of close-planting have not yet manifested themselves.

In Ceylon the fact that so very little flat land has been available for planting rubber trees, for the reasons already stated, helped to prevent matters becoming quite so bad in the older estates there as in the Federated Malay States. Still, the trouble is there also, and will become more and more manifest if drastic thinning-out is not speedily done. At such close distances as mentioned above no cultivation of the soil is possible. It will surely be admitted that cultivation is a necessity if trees are to be grown to the best advantage. Yet those responsible for the management of many estates do not appear to think so. Most planters appear to agree that not more than fifty coconut trees should be planted out per acre, and yet the same people plant out a hundred or more—often very much more—rubber trees to the acre.

Why?

The reason why fifty coconut trees are planted per acre is that long experience has shown that the trees grow better than if planted closer. Long experience has shown that the coconut trees can thus be better cultivated. Long experience has proved that coconut trees at wide distances have a longer life. Finally, long experience has shown, in numbers of nuts which can be counted, that more nuts per acre and of much larger size are obtained from trees widely planted. It is better to gather sixty nuts of good size from each tree, fifty trees to the acre, and have a total of 3000 nuts per acre per annum, than to gather thirty nuts per tree from eighty trees per acre and find that the total number of nuts gathered per annum is only 2400, while the weight of the copra of these 2400 nuts is only equal to the weight of 1500 of the nuts of more widely-planted trees.

The mistakes of rubber planters have arisen from the fact that they have had no experience behind them for a guide. Hence the indecision as to planting distances.

One manager concludes that 18 feet by 18 feet, which allows 134 trees to the acre, is a reasonable distance from which he may obtain the best yield per acre. Another thinks 15 feet by 15 feet, which allows 193 trees to the acre, will yield much higher results. All fear that if the number of trees per acre is reduced the total output per acre will be smaller. The welfare of each individual tree seems scarcely to enter into their calculations. The one idea which occupies the mind is—How can we get the biggest output?

In the first place, let us note that, if a rubber plantation is to be a permanent investment, one cannot afford to ignore, or even to treat as a secondary matter, the welfare, the health and the longevity of the trees.

The present planted areas of many of the older estates are, as pointed out, in a very critical state in very many cases. Large areas are being, perforce, rested, and yields fall off or do not increase, bark does not renew well, the foliage on the trees is decreasing, the soil is becoming barren, the trees are starving. A new, more reasonable and less severe system of tapping will help, along with a drastic thinning-out, and the crisis no doubt will be safely surmounted, for a time at least, but these estates will not be able to maintain their places in the front rank.

It seems, then, well worthy of close consideration whether it would not be better to follow the example of the planter of coconut trees and plant rubber trees at wider distances than in the past.

The Hevea, under fair treatment, given space, light and air and cultivation, grows to more than twice the dimensions of a coconut tree. Its foliage has a spread very many times greater.

Its roots extend to much greater distances. The excision which its bark undergoes is a tax on its vitality, such as coconut trees are never subjected to. All these circumstances call for wide planting. For these reasons it would appear that such a distance as 30 feet by 30 feet, which would permit of forty-eight trees per acre, is not planting too widely. A distance such as this would permit of good root development—an important matter not generally taken into consideration. Such a distance would permit of fairly liberal supplies of light and air, allow of a wide expansion of the branches of the trees, and hence for a luxuriant foliage, every leaf of which would perform its function of liberating from the carbonic acid gas of the atmosphere the carbon necessary for the growth of the tree. Such a distance, again, would afford room for cultivation, which also ought to be regarded as necessary on every well-managed estate.

The advantages of wider planting are well illustrated by some statistics given in Mr Wright's well-known book, *Hevea Brasiliensis*. The figures refer to trees on a well-known estate in the Straits Settlements.

Planting Distance	Age	Average Girth	Increase in 6 Months
20′ × 20′	4½ years	20¼′	2¾′
36′ × 10′	4½ ,,	18¾′	1½′
18′ × 10′	4½ ,,	15¾′	1′

From these figures it will be observed that the closer the planting distances the smaller is the girth of the trees, and the increase of girth follows the same rule. The soil of this estate is not rich or the difference would have been far more strikingly apparent.

Some people have pointed out that, in its native habitat, the Hevea grows wild in the midst of the crowded jungle in Brazil, and argue from this that close-planting does not matter, that it is the natural condition in the jungles of Brazil. It is also the fact that most of the Hevea trees there are very poor trees indeed, and that the average of good trees fit for tapping does not exceed two, or at most three in the acre.

Man does not, as a rule, want shrubs, trees or animals in their natural condition. He sets himself to select, to cultivate, and to breed the best varieties. Many of the beautiful roses which in so many varieties of shape, size, colour and perfume adorn our gardens, have, by selection and cultivation for many long years, been evolved from the common briar. The luscious apples, also of many varieties, have been, by means of cultivation, grafting and pruning, improved out of recognition from the little sour crab-apple. The ancestor of the faithful dog—man's truest friend—is believed to have been the fierce and treacherous wolf. The sheep, the ox, the horse have all been bred and selected from poor and diminutive stock till they have reached their present advanced specialized state. No one wants any of these in their original natural state. Why should anyone, then, wish to grow Hevea trees under wild impoverished conditions? The argument in favour of such conditions does not bear examination.

Admitting that all these things are so, many planters will say they cannot afford to conduct their estates on ideal principles, but must take first, or, at least, equally, into consideration pounds, shillings and pence. They will argue—and not unreasonably—that they must conduct their estates so as to obtain not only profits but the largest profits possible. This cannot be objected to, provided that a sufficiently long view is taken. As already stated, rubber plantations ought to be regarded as a permanent investment, and should be conducted, if possible, so as to secure this desirable end. Therefore it would appear wise to secure this end, although it was at the sacrifice of a proportion of the profits. Others will argue that they will attain the same end by planting more closely in early stages, and, later on, thinning out to such a distance as indicated above should it become necessary. This, however, is not so, for the reasons already mentioned. Branches which, for want of light and air, have become deprived of all foliage and rotted off the trees, can never be replaced, even if the trees later on are given more abundant supplies of light and air. For these reasons, considered in the light of a permanent investment, rubber plantations ought to be planted up at sufficient distances from the commencement.

While admitting freely that, for the first two or three years of tapping, the yields of latex from trees planted at such a distance as 30 feet by 30 feet will be considerably less per acre than from trees planted 120 or 150 per acre, yet this will not be long the case. When the more widely-planted trees have arrived at the age of six or seven years they will be yielding considerably more, tree for tree, than those planted at closer distances. When the widely-planted trees reach the age of eight to nine years the yield per acre should equal, if not surpass, the yield per acre from closely-planted trees.

Every year thereafter should see very large augmentations of the latex yield. By the time the trees reach the age of from eleven to twelve years it may be anticipated that the yields per acre from the widely-planted trees will far exceed the yields per acre from closely-planted trees.

Mr R. M. Lyne, Government Director of Agriculture, Ceylon, in the course of an address delivered on 4th July, 1912, made the following statement:—

"We have brought in for exhibition some rubber, the produce of one month's tapping of a Hevea tree at Heneratgoda. It weighs 18 lbs. The tree goes on yielding in that proportion six months or more in the year. In $3\frac{1}{3}$ years it yielded 275 lbs. of rubber. What is the cause of this? I have heard it described as a freak, but I do not accept that solution. If we had been planting rubber for a hundred years, or if this tree stood in a plantation of 100,000 among others of like age and size, we might be justified in regarding it as a freak; but there are only a few trees on the island that can rank as its peers, and these are grouped round it. It is one of the original consignment imported from Brazil. This tree has never been manured, therefore manure has had nothing to do with its prolificacy. It grows on rather poor soil, therefore its abundant flow of latex is not due to exceptional richness of soil. We can thus eliminate three influences—individual peculiarity, manure, soil—and say that none of these has had anything to do with the rich return of this Hevea tree. What remains? To what other conditions is vigorous tree growth due? Light, air and room are three, and this tree, standing on the outside of the plantation, enjoys a liberal supply of all of these. Leaves cannot perform their functions without light, and, other things being equal, we may take it that the more light they receive during the hours of daylight, the more work they will do, and the more vigorous will the circulation of the tree become. The same may be said of air; while it will be obvious that the less the soil preserves of a tree are encroached upon by neighbours, the greater will be the stores of plant-food at its disposal to draw upon. But the most important factor of tree vitality yet remains to be indicated, namely, moisture. In the Tropics fertility follows in the track of the rain; and one of the functions of rain is to keep the water-table at its normal level. It is not unlikely that this large and vigorous Hevea may have succeeded in tapping subterranean reservoirs, as yet out of reach of its companions. Now, if this is so, and had this tree been subjected to systematic manuring, root development might have been encouraged towards the surface instead of towards the deeper layers of the soil, and in that case the water-table might never have been reached. We have here then a hypothetical case, and it seems to me not at all an unreasonable one, in which manuring might actually have done harm instead of good. You cannot, of course, argue from one tree, especially a tree that is a generation older than most rubber trees on the island. I have only taken it to illustrate the point I wish particularly to make, which is that, in the presence of natural forces working so very much more vigorously than we have been accustomed to in temperate climates, where the science of agriculture has been built up, it is possible we may be devoting too much attention to what I will term the artificial side of rubber cultivation—manuring and methods of tapping—and that we might achieve better results at first by devoting our energies more to removing obstacles from the path of Nature and giving her rein. We should endeavour to secure, as far as we can, that Nature has full scope for the use of her vast resources with each individual tree in the plantation, and that each individual tree is given full play for the utmost exercise of its functions. After that we may begin cautiously to offer her assistance with such puny means as we have at our disposal, being ever watchful that, instead of helping her, we may not be hampering her."

Mr Lyne's observations are very much to the point, and it would be well if more of the gentlemen with some training in the sciences in the service of the various Governments preached from the same text. He seems, however, to ignore the essential part filled by the microscopic soil flora in relation to soil fertility.

All will agree that a strong, deep-reaching tap-root is a most desirable thing for a tree to possess, but the lateral roots have a totally different function to perform. They have to receive and forward to the foliage the nitrogen and ammonia supplied through the agency of bacteria, and mineral salts, and the deeper into the soil the roots force their way the fewer are the bacteria, unless the soil is well drained, well broken up and well aerated, as the bacteria must breathe. If the sub-soil can be made habitable for the roots, then fresh and abundant stores of mineral salts (but seldom of organic remains) can be drawn upon and additional roots will be developed to draw upon them, to the very great benefit of the tree.

Take an instance in point out of many which could be cited. On Pangkattan Estate, in the Bila district of Sumatra, belonging to the Sumatra Para Company, there are three isolated trees which, from special circumstances, have enjoyed all the advantages of wide planting. These trees were in April, 1912, eleven years of age. Owing to their isolated situation they have had abundant supplies of light and air. The roots of the trees were exceedingly well developed and could be traced to great distances, say over 80 feet. Each tree had a fine spread of foliage.

Each tree yielded over 100 lbs. of dry rubber per annum!

It can readily be calculated that if one had forty-eight trees to the acre, each yielding 100 lbs. of dry rubber per annum, the total yield per acre would be 4800 lbs. As 400 lbs. per acre is considered a very good yield from closely-planted trees, it will be seen that, if such yields could be obtained from widely-planted trees, 1 acre of widely-planted trees would be equal to 12 acres of trees closely planted.

Supposing, however, it were to be claimed that the three trees were unusually fine specimens and the yield from them abnormal. Yet it can scarcely be contended that it was due to the trees themselves, and not to the advantages of wide-planting that they enjoyed, that the yields of latex were so enormous.

It seems reasonable to argue that the ample room which these trees possessed to develop their roots in the soil, and the abundant supplies of light and air which they enjoyed, had a great influence upon the matter. Admitting freely that all trees widely planted might not be equally successful, yet surely one might reckon that they would obtain, in a fair measure, the same results.

If the results obtained were only one-fourth as good as those obtained on Pangkattan Estate, they would still be three times as good as those obtained on an ordinary plantation.

There would, in addition, be further substantial advantages. These trees having a healthy development denied to closely-planted trees, would, as a matter of certainty, have a longevity denied to closely-planted trees, thus making the rubber plantation more of the nature of a permanent investment.

Further, with only forty-eight trees to tap per acre, instead of, say, one hundred and fifty, the costs of tapping, of tools and of utensils would be considerably less. This is a matter not to be overlooked. Days of low prices may come, and such things as this may be important factors.

With only forty-eight trees to the acre each individual tree could receive an attention impossible with, say, one hundred and fifty trees to the acre. To plant out forty-eight trees to the acre should cost a little less than one hundred and fifty trees. To manure the young plants should certainly cost less with forty-eight trees than with one hundred and fifty, and this good start in life might thus come more readily within the means of the planter.

It is of course not contended that all estates will give the same results. There are estates at too high elevations, estates with sandy soils, and estates with too low a rainfall. Yet, wherever cultivation is possible, it will be found to improve the growth of the trees, and light and air are necessary to rubber wherever it is grown. As the result of cultivation one estate in Sumatra had a yield of over 1250 lbs. per acre from its oldest rubber, which is quite in excess of yields generally obtained and points to what can be done.

In certain countries and certain districts dry, hot winds prevail at certain seasons and not only greatly retard the growth of the trees, but almost entirely arrest for the time being the process of carbon assimilation by the leaves. This, of course, means, for the time, a stoppage of food-supplies and throws the tree back on its reserve stores of food-supplies. The reason of this is that the continued winds dry up the film of moisture

FIG. 30.—Three Eleven-year-old Trees on Pangkattan Estate, Sumatra, showing Good Growth and Root Development because Uncrowded.

within the stomata or minute mouths of the leaves and the process of converting the carbonic acid gas of the atmosphere into carbon compounds perforce ceases. In such districts trees grown too far apart may be somewhat slower of growth during their early years.

A good practice, in such cases, perhaps in all cases, would be to plant the trees in clumps of threes, each tree 15 feet apart from the other two and each clump of trees at least 35 feet apart from the nearest tree of another clump. In this way each tree, while affording some shelter to its neighbours, gets an abundant supply of light and air from three sides, and also room for a wide expansion of roots without interfering much with the other trees. This system offers many advantages and is to be commended. The best specimens of not only rubber trees but very many other varieties are found growing in such clumps.

Failing this, the best method is to plant the trees in east and west avenues 15 feet by 30 feet, which, while affording shelter and giving a large number (ninety-six) of trees to the acre, allowing thinning later, yet gives a good supply of light and air to two sides of the trees and allows for cultivation between the rows. The objection some have to this method is that it tends to make the branch-system of the trees somewhat lop-sided. It is, however, better to have trees well-developed in two directions than very poorly developed in all directions, as is the case when they are closely planted in the ordinary way.

It is almost unnecessary to state that when wide planting is gone in for, more care must be bestowed on the selection of the original plants, on their upkeep and on the cultivation of the soil, than when there is such a large number of trees to the acre that vacancies cause little or no concern. A vacancy when there are only fifty or sixty trees to the acre is a more serious thing than when there are one or two hundred trees on the same area of land. Of course too much emphasis can be laid on this point. When one plants only fifty trees or sixty trees to the acre one can very well afford to select only the very best and most vigorous seedlings. In the second place, one can also well afford to dig wide holes when there are only fifty or sixty to be dug instead of, say, one hundred and fifty holes. The advantage of this is pointed out elsewhere. Then, further vacancies for the most part occur when the trees are very young and the vacancies can be economically re-supplied.

Several of the best-known visiting agents and estate managers in the Federated Malay States and Straits Settlements have acknowledged that they agree that forty-eight trees, or even less, per acre are sufficient and would give as good if not better returns per acre, but they are somewhat timid in pressing their convictions upon their board of directors. This, while natural, is to be regretted. It is especially to be regretted when additional areas are being planted up at distances that the manager and the visiting agents condemn in their hearts. One can sympathize with them, however, in their endeavours to make the changes in existing conditions on planted land a gradual process. Boards of directors, as a rule, are conservative. They do not like changes. A change which would very materially reduce the number of the trees on their estates would not readily commend itself to them, and it is felt that the process of education must, of necessity, be a slow one. Still, there is no doubt that the change in favour of a system of wide-planting is approaching. The sooner it comes about the better for the rubber-planting industry. The old estates have reaped handsome profits in the past, but the future is for the younger estates planted on a saner system. No doubt, however, much is being done, and will be done, to improve the condition of the older estates by severe thinning-out.

This whole subject of proper distances for planting-out is one which might very well be taken in hand by the Governments of Ceylon and the Federated Malay States. The best scientific advice should be engaged to help in this important work. The prosperity of the Middle East is largely based on the welfare and success of the rubber-planting industry, and there can be no proper condition of plant sanitation so long as planting distances are too close.

"The life of trees is as the life of man." While it is true that under favourable conditions a Hevea can attain a good old age, yet it is by no means every tree that does so. A fairly close parallel can be legitimately drawn between the duration of life of the Heveas and that of mankind. In infancy, in both cases, the mortality is very heavy. The diseases, risks and accidents to which helpless human infants are liable have their counterparts (generally dissimilar now that humanity has become generally civilized, but in a savage state of existence not so dissimilar as might be supposed) in the diseases, accidents and risks which exact a heavy toll from young plants.

During the childhood, as it might be described, of the young trees, the mortality—although not quite as excessive as in their infancy—is still comparatively great. The vacancies in the case of young trees can, fortunately, be easily supplied. The survivors, as in the case of humanity, have then a fair expectation of life, as assurance society tables put it. Yet disease and death are always at work thinning the ranks. Just as it is with ourselves,—other individuals take their places: the mass is, more or less, always there, and the world moves on. As years pass the survivors of the original band are few and show all the signs of age. One or two hoary giants survive for an apparently long period, but the day comes when their place knows them no more. The vacant spaces left by the decay and death of ancient Hevea trees will, no doubt, in due course be filled up, but this will be a matter for the attention of another generation of planters and need not specially concern us.

CHAPTER XIX

WOUNDS ON TREES

WHERE these are quite small they usually heal readily enough without causing trouble other than the possible appearance of burr growths, as discussed elsewhere. If moderately large, a touch of tar or a wash over with permanganate of potash is advisable to obviate the chance of the tree being attacked by fungoid diseases. Large wounds are frequently observed, especially near roadsides, where the passing coolies, out of pure devilment, often give trees a slash with their parangs. At other times the wheels of passing carts graze trees and sometimes do serious damage.

Wounds, and large wounds too, are sometimes made intentionally, when large developments of burr growths have to be cut out in order to restore the trunks of trees to a condition in which it would be possible to tap them by ordinary methods. Such large wounds would be very slow of healing—if they healed at all—if left to themselves, and in such cases the risks of fungal disease would be very grave indeed. To reduce these risks, and to assist Nature in her work of healing, planters frequently poultice over the wounds.

The following is a good mixture to use when applying such a protective covering:—

2 lb. sulphur.
4 lb. unslaked lime.
7 lb. cow-dung.

These should be well mixed up and boiled together with just sufficient water to enable them to form a thick paste. Before applying the mixture to the tree it is well to wash over the wounds with a solution of permanganate of potash, one of the cheapest, most harmless, most easily handled, and yet at the same time most thoroughly effective of all disinfectants. When the paste is cool a poultice of the mixture should be closely applied—or it is of no use—and tightly bound on to the tree over the wound. It is a wise precaution for all planters to have a small tinful of permanganate of potash in their bungalows, as, in the case of wounds to any of the staff, or of the coolies, there is no better disinfectant of such wounds. Planters should not disdain to treat even small wounds such as cut fingers with a wash over of this disinfectant and thus obviate risks of blood-poisoning always present in tropical climates.

CHAPTER XX

THE LATEX AND HOW IT IS COAGULATED

WHAT exactly is latex? and what useful purpose does it serve in the economy of the tree? are questions often discussed but never satisfactorily answered. The Darwinian theory that in the struggle for existence a variation is only apt to survive when of value to the possessor seems out of focus here as in very many other cases. Scientific authorities are fond of warning us not to think of any attribute of plant or animal life as having been evolved for the benefit of humanity at large. This, they warn us, is a crude, ignorant and conceited idea for which there is no warrant.

To the mere materialist of course this is self-evident. It is done and disposed of. Discussion is futile and a mere beating of the air; yet, to those who realize a harmony and evident co-operation in the universe, this loud-voiced utterance has an empty sound. There is a co-operation in Nature, often unwitting, of even the most discordant elements.

If, as is recognized by all, a cell in a root can work in co-operation with a far-away, out-of-sight cell in the leaf on the tip of a branch and send up to it solutions of food apparently knowing that a portion of these will be returned in a manufactured form for its nourishment and growth as its share—is not that an instance of what may take place on a wider scale? Nay, more, if the pollen cells on one tree can be set free to fertilize the female elements in the ovules on another tree at a distance, surely it is not an undue stretch of the imagination to suppose that the Designer of the Universe—if His existence is to be permitted by some of our wiseacres—could have a purpose for the laticiferous cells of the Hevea outside the tree itself.

Indeed, the co-operation in Nature has a wider scope than many dream of. Take the extraordinary instance cited by

Darwin, for example, of how the existence of the common clover depends on the old maids living in the country. The explanation is as follows:—The clover is only fertilized by the humble-bee. The nests in the ground of the humble-bee are ravaged by field-mice which greedily devour their winter provision of honey. The humble-bees would perish and the clover would not be fertilized but for the fact that there are many old maids living in the country and these old maids keep cats, which cats hunt the field-mice and keep them down. Thus, through the existence of these unmarried ladies with their domesticated pets, the bees are enabled to survive and fulfil their task of carrying the pollen from one clover-plant to the other and so fertilizing them.

The plant food reserves in latex are very small and amount at most to only about 2 per cent. of the volume. These are entangled with other elements of no service as food reserves. If latex is intended as a food reserve the tree has gone very badly about its business and has shown none of the ability which it has displayed in so many other directions. In the endeavour to prove the theory that rubber latex is a food reserve, chemists have hunted for an enzyme, *i.e.*, active fermenting agent in the latex, which would render available the protein matters associated with the minute globules of caoutchouc. This has not yet been found. In any case the amount of protein is very small. The essential hydrocarbon of crude rubber, the rubber element proper, which forms 90 to 95 per cent. of the solids in plantation rubber, appears a most unpromising food material, and few have ever held out much hope for the belief that it can be utilized by the tree. It is as if the tree had locked up these stores in a strong room and had lost the key. Only those with a knowledge of advanced chemistry can understand the difficulties which the tree would have to face to render such stores available.

Dr Stevens has pointed out that the resins in trees must be stores of plant food also if latex is. In such case the possibility of drawing upon these resins appears most remote and discredits the theory of plant food stores more than ever.

There might be more warrant for considering the function of latex to be the arming of the tree against insect attacks, but in that case the tree has much over-loaded itself and wasted much effort which could have been more usefully employed in a less degree and at less expense.

As a storage of water-supplies latex is again a poor contrivance on the part of the tree, if, as said by some, that is the idea it has in view. This is the weakest suggestion. The tree is a habitant, not of arid sands and regions of minimum rainfalls, but of moist soils and districts with abundant showers.

There are still others who argue that latex also consists of excretory matter of the tree cells which empties into the channels through which pass food supplies. It is true that some plants are supposed to excrete poisonous matters from their systems, but one would scarcely expect an advanced tree like the Hevea to deliver its excretions into its pantry. The function, then, of latex considered purely from the tree's point of view is somewhat obscure. No doubt many are prepared to pronounce with confidence on the subject, but to such one might say, as Disraeli said to an over-confident and conceited junior, " My dear fellow, always remember that none of us, not even the youngest, is infallible! "

The latex of the Hevea is composed of an alkaline fluid in which the minute globules of caoutchouc are held in a state of suspension. In this fluid, in a state of solution, are small percentages of sugars and various proteins, while starch-grains and resins also are present. Latex is usually of a bluish-white colour, but, on occasion, is yellow and sometimes almost black. While the latex of very young trees contains a slightly higher proportion of resins than that of more mature trees, the rubber from young trees has practically the same composition as rubber from old trees when tested by chemical analysis. That does not mean that the one rubber is equal in quality to the other. The chemical analysis of many products is the same, although the articles are very widely different. Glucose and malt extract, for example, have the same chemical composition, but malt extract is a very different thing from glucose and can convert starches into sugars while glucose leaves them untouched. To take a case more common: the cellulose of wood pulp has the same chemical composition as the cellulose of cotton, but nothing like the same tensile strength. The fact is that chemical analysis, while helpful, cannot be relied upon as a final test. With rubber the final test is vulcanization. It

FIG. 31.—Carrier Cart conveying Coagulated Latex from Outlying Portion of Estate to Factory.

FIG. 31A.—View on Kepitigalla Estate, Ceylon. Elephants waiting to convey Rubber Chests to Railway.

will probably be found that rubber from old trees yields the superior finished product.

Black, discoloured latex is sometimes yielded by certain trees, especially during very dry weather. This is often very puzzling to planters, who are at a loss to account for the phenomenon, and often very wild theories are suggested. This discolouring of latex is accounted for to some extent by an excess of tannic acid in the bark of certain trees, owing, perhaps, to some peculiar local condition of the soil. The latex is not really black, but has a dark, discoloured, streaky appearance. As a general rule most of the discoloration disappears gradually from the rubber sheets as they dry. The sheets may at first show dark streaks, but these in most cases, at all events, seem to fade away as the sheets become dry.

It is most important that, before latex is poured into the Shanghai jars or other receptacles for the purpose of coagulation, that the latex be well strained through wire sieves. If too thick to pass readily through, water should be added. This is seldom necessary, and the less water added to latex at any time the better. The sieving intercepts many impurities which would otherwise lower the quality of the rubber and, in some cases, might do damage in the washing machines.

If first-grade rubber is to be of best quality and colour the lump rubber should not be put into the Shanghai jars or rubbed through the strainer. It should be kept apart and put through the mills by itself.

To make certain of obtaining clean rubber, the usual practice on some of the best estates is to stir the latex well round with a stick after it has been strained through into the Shanghai jars. After it has been well stirred round, the surface is skimmed with a ladle, and it is then stirred a second time and again skimmed. The careful attention thus given removes many impurities which have passed through the sieves and greatly improves the quality and the colour of the rubber subsequently made. The skimmings should not be thrown away but added to some of the lowest-grade rubbers. The removal of all scum is essential, as otherwise fermentation is apt to set in, and the sheets of rubber in such a case are often discoloured.

Latex should never be exposed to sunlight, as that stimulates chemical action, from which discoloration is certain to follow.

Coagulation is usually effected by means of the addition of acetic acid. The general amount of acetic acid added to the latex is, in most cases, three to four drops of the glacial acid to the gallon of latex. Most planters dilute the acetic acid with water, for greater convenience of measurement, and have marked glasses, which are filled by the coolies up to the point marked out of the glass jars containing the diluted mixture. As the latex is usually emptied from the buckets into large Shanghai earthenware jars, it is easy to regulate the quantity of acetic acid which should be added. Complete coagulation should leave the remaining liquid clear. When it becomes turbid or milky it is a sign that complete coagulation has not been effected.

It is now a part of the general routine of rubber manufacture on many leading estates to add some sodium bisulphite to the latex after it has been sieved and before it is skimmed. The acetic acid is added thereafter. This sodium bisulphite not only acts as an antiseptic, but also preserves the colour of the rubber. Fermentations arise very rapidly in the latex, and unless promptly checked by such means as this tend to discoloration of the rubber sheets. This will be most readily observed when latex is coagulated in field-sheds at a distance from the factory. The rubber made from latex so coagulated is always lower in shade. On some estates endeavour is made to obviate this by more thoroughly expressing the water from the coagulated latex by heavy hand machines, but even this precaution does not prevent a lower colour. One half-pound of sodium bisulphite mixed with one gallon of water is about the usual strength of the solution employed. It should be very thoroughly stirred in or the rubber will be streaky. This quantity is sufficient for 20 to 25 gallons of latex. The sodium bisulphite pays for itself, as very careful investigation goes to show that by its addition the total weight of the rubber obtained is increased by a weight in excess of that of the sodium bisulphite itself. The reason of this is at present obscure. The addition in weight is equivalent to 1 per cent. in ordinary practice. Not only does sodium bisulphite check discoloration, but it also to some extent improves or, rather, perhaps

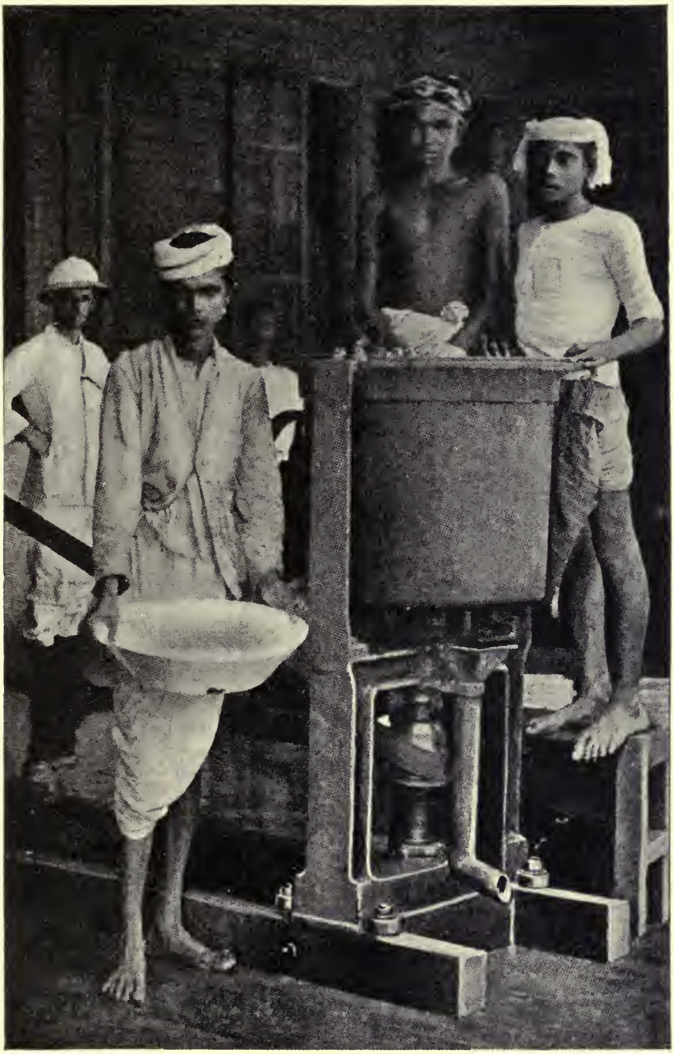

FIG. 32.—The Michie-Golledge Coagulator (Walker & Sons).

one should say, preserves the quality of the rubber. The reason of this is apparent. Any fermentations arising, however slight, attack the nerve of the rubber, and if allowed to proceed to any length the rubber would become tacky. Sodium bisulphite has antiseptic qualities and thus prevents these fermentations arising or checks them promptly if they have started. It is, therefore, obvious that if sodium bisulphite is to be added to the latex it should be added as soon as is possible. It may well be the case—and it is suggested here—that it would be a good thing if using water in tapping operations to use a very weak solution of this sort instead of ordinary water. The objection to the use of water—that it assists the arising of ferments—could not be cited, but, on the contrary, the solution would have the desirable effect of hindering ferments arising at the first stage of the proceedings. In this way it is possible that a very high grade of rubber might be produced and lump rubber reduced to the vanishing point.

Each manager should carefully experiment for himself and ascertain what is the smallest quantity of sodium bisulphite powder which will give him the best results in colour and quality. Sodium bisulphite very readily absorbs moisture and should be carefully kept in a very dry place—not in the factory—or it will lose its qualities. After lower-grade rubbers, such as scrap, bark-shaving rubber and earth rubber, have been cleansed of the impurities associated with them, a wash over with a weak solution of sodium bisulphite will have the effect of improving their colour and their keeping qualities. The best results are obtained when the solution is prepared fresh as required. When smoked is manufactured instead of pale crêpe, there is little or no excuse to use sodium bisulphite.

Latex will coagulate without the addition of any acid if left to stand long enough, but the rubber is not so good a quality, nor would this method be convenient in factory operations where dispatch is of the utmost importance.

There are many proprietary coagulants on the markets, but acetic acid is generally found to be the most serviceable. The scrap rubber which dries upon the trees is stronger than the coagulated first-latex qualities. This fact suggests that there is yet room for improvement, and that we may have yet to learn the best method of preparing rubber.

In the Michie-Golledge system the rubber is separated from the latex with the use of a little acid, aided by centrifugal action. On some plantations the separated rubber, after being worked into sheets, is cut into shreds—" worms "—to facilitate drying, and these dried " worms " are finally rolled together into characteristic crêpe-like strips. This latter part of the process involves the employment of additional machinery for cutting the sheets into shreds, and although in use on some Ceylon estates of high reputation, appears to be an altogether unnecessary proceeding, especially when hot air or vacuum driers are at hand.

A number of methods have been devised for the coagulation of latex by means of smoke, with the idea that the smoke will

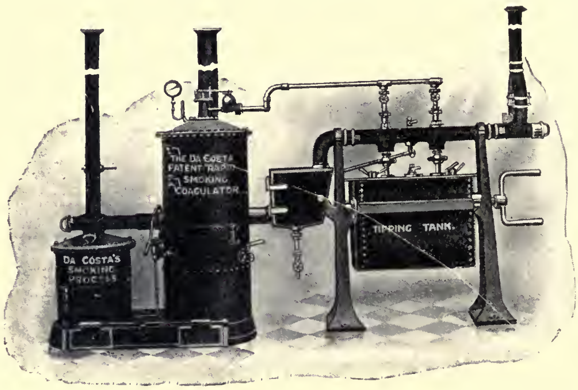

FIG. 32A.—The Da Costa Smoker Coagulator (Bridge & Co.).

act as an antiseptic as well as a coagulating agent. One of these methods is that of the Da Costa Smoker Coagulator. A mixture of low pressure steam with wood smoke filtered through baffle-plates is injected into the latex in a trough. The force of the steam agitates the latex sufficiently to bring the smoke into contact with every part. In a partly similar apparatus made by Messrs Shaw, compressed air is used instead of steam.

A convenience which is being introduced into a number of estates is the coagulating trough. These are mounted on a mound of cement, so as to be easily reached without stooping. In the top of the cement mound is the trough, which is lined with white glazed tiles. The sides of the troughs are only one tile in height. The troughs are usually about 12 feet long by

3 feet wide. Wooden slips are used to divide the trough into conveniently-sized squares. The latex is poured into the trough and coagulated. After it is coagulated the wooden slips are lifted out and the coagulated latex is found to be in conveniently-sized blocks, which do not require to be cut up before being put through the mills.

The objections to these troughs are the difficulty in the way

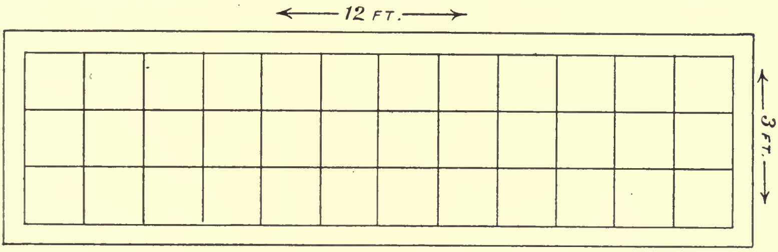

FIG 33.—Surface View of Coagulating Trough.

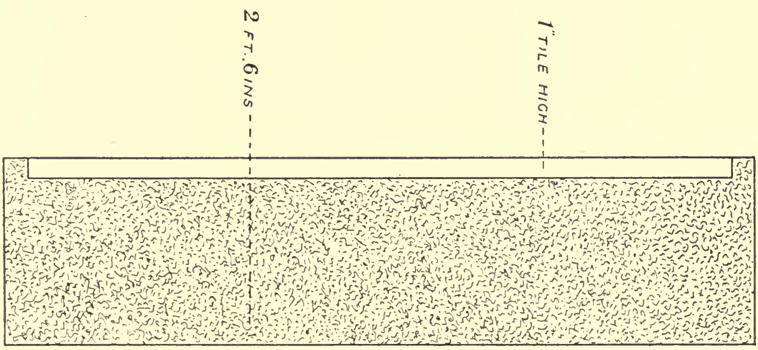

FIG. 34.—Side View of Coagulating Trough.

of properly skimming the latex and the use of the wooden cross clips to divide the rubber into conveniently-sized blocks. No wooden article should be repeatedly used in the treatment of latex, as it is apt to become infected with fungus. The same objection, therefore, applies to the use of wooden tables, on which lumps of coagulated latex are laid just in front of the machines, within convenient reach of the coolies running the mills, and on which the sheets of rubber are often thrown as they have been finished at a particular mill. All such tables should be constructed of solid cement and covered with white glazed tiles, which by their nature are impervious to moisture and easily scoured clean. If coagulating troughs are to be used, the cross-section slips should be of metal.

The red spots which sometimes disfigure rubber sheets, and which planters are at their wits' end to get rid of, are minute bacterial growths, if not also fungal. They specially infect wooden articles. The only way to get rid of them is by thoroughly scalding and disinfecting with strong disinfectants all the factory and all articles in use there. This should be done two or three successive times, as the fungi are most difficult to eradicate, having both a wonderful fecundity and more lives than any cat that ever lived. Cleanliness in the factory cannot be too strongly insisted on.

With a view to obviating the risks of attacks of such fungi the manager should see that no wooden tables are in use in the factory. If of wood, they should be covered over with zinc. Cement mounds with glazed white tile tops are much better for factory purposes than wooden tables. A wooden stick ought not to be used to stir round the coagulated latex. It will become infected after a time. If used, it should not be used too long, but be replaced by fresh rods. A light metal stirrer is the safest.

In every well-managed factory a very careful record should be kept, not only of the total daily amount of rubber of each grade manufactured, but of their relative percentages. In this way a manager has a check on the working of the productive portion of the estate which he could arrive at by no other means. For example, he is able to observe whether scrap rubber and earth rubber are being properly and regularly collected, and what percentages these are of his total output. He is able, by watching over such details—generally neglected on the great majority of estates—in course of time to reduce these percentages and to add to the percentage of the first-grade latex rubber, which all will admit is eminently desirable. Sometimes, too, this record may be the means of awakening a manager to the fact that systematic pilfering of scrap is going on to a large scale, and enable him to stop it.

With such records in their possession managers can compare notes with each other from time to time and improve their factory practice very materially. Here is another opportunity for efficiency in working and one which should not be neglected.

CHAPTER XXI

TAPPING

THE object of all well-considered tapping should be to get as much latex as possible from the trees with the smallest excision of bark convenient, so as not to interfere, or to interfere as little as can be helped, with the health of the trees and their capacity for continuing to yield latex year after year during a long lifetime.

During severe droughts it is frequently advisable to cease tapping operations for a time. The trees need all their vitality to stand the effects of the drought, and the additional strain caused by tapping operations at such times is apt to affect the general health of the tree and hinder its recovery from the effects of the drought. Apart from these reasons it is wasteful policy to pare away bark for such very small returns of latex as are customary in times of severe drought. There are other times when it may be advisable to reduce at least the extent of tapping operations, such as when trees are wintering. At this season of the year the trees, having no foliage, are receiving no additional supplies of plant-food from day to day, and are simply living on their reserve stocks of food-supplies.

It is seldom worth while to start tapping operations unless at least 50 per cent. of the trees on a given area are of sufficient girth to make tapping operations advisable. Eighteen inches of girth, at 3 feet from the ground, is the generally-recognized dimension at which tapping may be properly commenced. Some planters favour 20 inches girth at 3 feet from the ground, while in practice on many estates one sees trees of 15 inches girth at 3 feet from the ground being vigorously tapped.

Tapping, especially severe tapping, undoubtedly interferes with the growth of the trees. The best-yielding trees known to the writer were not tapped till nine years of age. It is an open question whether it would not well repay estates to delay tapping till the trees are seven or eight years of age. If the exigencies of finance would not permit this on too widespread a scale, it would be well worth while to reserve a limited area of say 50 acres, and later on compare the returns from the 50 acres untapped till the trees had arrived at the age of eight years with similar areas tapped in the ordinary way. It would not be at all surprising to find that the returns from the former greatly exceeded the returns from the latter. The reasons for this would be twofold. First, the trees would be more healthy and vigorous owing to their not having been bled of their food-supplies by the cutting away of bark, the drawing off of latex and the interference with the channels which distribute food-supplies to the various parts of the trees. Second, the trees being better grown, there would be an increased tapping-area of bark available.

Some planters contend that the returns of latex from cuts made on the left-hand side of the downward conducting-channel are markedly greater than those from the right-hand side. Others as stoutly deny that it is so in their experience. As the whole circumference of the trunk of the tree has to be tapped at one time or other up to a reasonable height, there does not seem to be much in the point to concern one, if there is any point in it, which does not seem probable.

When the first few Hevea rubber trees planted in the Middle East came to the bearing stage the planters had no idea how they were to get the rubber out of them. In Ceylon, as in the Federated Malay States, the planters attacked the trees with axes and knives and slashed them all over the stems. When the latex ran out and dried on the tree stems it was rolled up into balls and shipped off to the London market, where first consignments fetched from two shillings and ninepence to three shillings per pound. It was soon obvious to planters that more refined methods of tapping must be employed.

Small V cuts all over the bark succeeded the system of general slashing, but were found to leave the bark in a very rough and irregular state. Indeed, the small V cuts and the use of the pricker were the cause of the death of an immense number of fine old trees which, with reasonable treatment, might have been alive and yielding large returns at the present day. The trees which have survived such treatment show by

FIG. 35.—An Old Rubber Tree showing the Results of previous Bad Tapping.

their swollen trunks, covered with growths of burrs, and by their rough, corrugated bark, how much they resented the ill-usage. Many such trees are still to be found in Ceylon, Sumatra and elsewhere, and serve the purpose of an object-lesson.

There is no more fatal system of tapping than the use of the pricker, still advocated by some. Undoubtedly the yields of latex are, for a time, much increased by its use, but these increased yields have to be paid for very dearly indeed later on. The wounding of the cambium of the tree by the pricker is always followed by such an extraordinary development of burr growths and abnormal swellings that no smooth portions are left on the bark of the trunks where it is possible to tap the trees.

By cutting out the growths, by manuring and resting the trees, it has been possible to recover a good many of such trees, both in Ceylon and Sumatra, but by far the greater number have died out.

It is said that Mr R. W. Harrison was the first to introduce into Ceylon the system of paring away thin shavings of the bark from the same incision, which is now generally followed, but the system had been experimented with in the Federated Malay States previous to that date. Those who have studied the short, simple account of the physiology of the Hevea tree given in earlier chapters must realize that, by cutting away strips of bark, they are interfering with the course of the flow of manufactured plant-food downwards through the cortex. The length, the depth, and the number of the cuts determine the extent of such interference.

When, as in the case of the now abandoned full-spiral system of tapping, the tree was entirely girdled with cuts, the entire downward movement of food-supplies was practically suspended, and but for the reserves of starch food stored by the trees below the cuts they would have eventually died if the system had been long continued.

Some experiments made at Henaratgoda in September, 1907, went to show that Hevea trees would for a long time survive even complete girdling of the trunks of the trees. This was due to the fact that the Hevea is a tree of comparatively rapid growth, and in trees of rapid growth the sap-wood is thicker and the tree is not so soon killed as the slow-growing trees.

It is very doubtful, however, whether Heveas would long survive the continual girdling involved in the operations of full-spiral tapping. In any case planters soon became fully convinced that the system was too drastic and too dangerous, and it was finally entirely abandoned.

The systems of tapping in general use in the present day, while often too severe, are at least a good deal less severe on the stamina of the trees than the full-spiral system was. The full-herring-bone, the half-herring-bone and the basal V, or modification of these, are the most popular.

It is only in cases where, from former ill-usage, the bark of trees is too rough for ordinary methods that single small V cuts are ever employed nowadays.

Both the herring-bone and the half-herring-bone systems of tapping have been naturally evolved out of the original V tapping. With one V cut above another it was a natural thing to connect two or small channels so that one cup would prove sufficient to serve several cuts. In course of time the V cuts were widened, lengthened, and, being connected by channels, became a series of symmetrical, broad V tappings. In order to interfere as little as possible with the circulation of plant-food through the bark, the V cuts were so adjusted as to form the full-herring-bone system.

Still later, the full-herring-bone system being thought to be severe upon the trees, and not allowing a sufficient time for bark renewal, the half-herring-bone system, at present in general use on so many estates, was introduced. By this system only half the amount of bark is used up which was excised under the full-herring-bone system. Such, in few words, is a brief résumé of the evolution of tapping methods up to the present date. The last word on the subject has not yet been written and further changes are in view.

The majority of the laticiferous vessels in the trunks of the Hevea trees are found just outside the cambium. It is important, when tapping, that the knife should reach these vessels in order to obtain a good flow of latex, but that at the same time the very greatest care should be exercised by the coolies not to wound the cambium.

Where wounds have been made there is nearly always a swelling of the stem of the tree at the wounded spot. This

FIG. 36.—An Old Tree overgrown with Burrs as the result of Bad Tapping.

interferes with the smoothness of the bark and, consequently, presents difficulties for subsequent tappings of the renewed bark. These swellings are frequently accompanied by the development of burrs, which are apt to spread over adjoining portions of the stem of the tree.

It is, of course, essential to see that the tapping is done to a

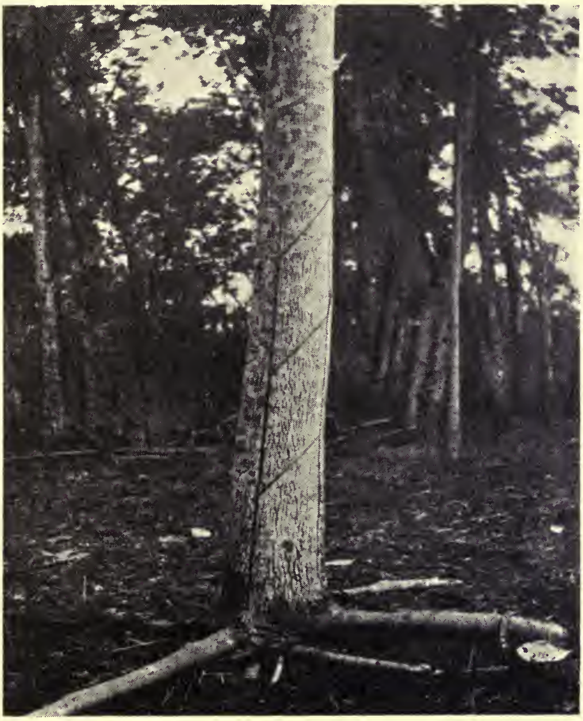

FIG. 37.—Tree marked ready for Tapping.

sufficient depth, and one tapping assistant to supervise every 250 to 300 acres in tapping is not too many.

On one East Java estate, where tapping had been in progress for nearly a year, the sheets of rubber were of such uncommon strength as to cause general remark. The cause of this apparent anomaly, since the rubber was produced from very young trees, was found on investigation to be that the tapping was of the lightest possible description at the surface. The yields of latex were extremely meagre, but, as stated, the rubber was of very unusual strength.

Tapping on young trees of 24 inches girth and under 3 feet from the ground should never be done higher than 3 to 4 feet from the ground.

High tapping is bad tapping, everywhere and all the time.

Before starting to tap, the coolies should see that the trunk of the tree is clean and free from dust. If the bark is very rough, it should be scraped down with the back of the knife. The bark should not be too severely scraped so as to show green, or damage will be done, and probably latex will exude.

For many systems of tapping, where there are several cuts on the bark of the tree one over the other, it is very advisable to mark the trees with light scores on the bark so as to secure regularity of the tapping lines. It is a very common fault of coolies when tapping to lean more heavily at the end of a cut and take off a thicker paring than is done at the beginning of the cut. This "drooping," as it is called, is very troublesome. If not checked, small areas of bark are apt to be left isolated or untapped.

When tapping is first started on young trees what is called the basal V is the method most generally adopted. Very good yields are in most cases obtained from this style of tapping. Mr W. J. Gallagher, late Director of Agriculture, Federated Malay States, however, strongly condemns it. In a pamphlet published in April, 1910, he states as follows:—

"Equally bad is the system sometimes followed on young trees of putting on a V-shaped cut, each of which goes half-way round the tree. An attempt has been made to minimize the evil of this by leaving a strip of bark 1 inch wide on each side between the cuts. This is soon found to be insufficient. As the material which should go to the roots and all the area below the cuts is stopped when it reaches them, not alone do the upper borders of the cuts renew rapidly, but there is an excessive growth above them and no growth or very little growth below them, with the abnormal result that the tree becomes greater in girth above than it is below the area being tapped.

FIG. 38.—A Well-tapped Tree, so far as the Execution of Work is concerned. Fourth Year of Tapping.

" The latex flow and returns begin to fall off decidedly after five or six months' tapping.

" There is a further objection to this method. You cannot always tap in this way. You must sooner or later divide the tree into quarters."

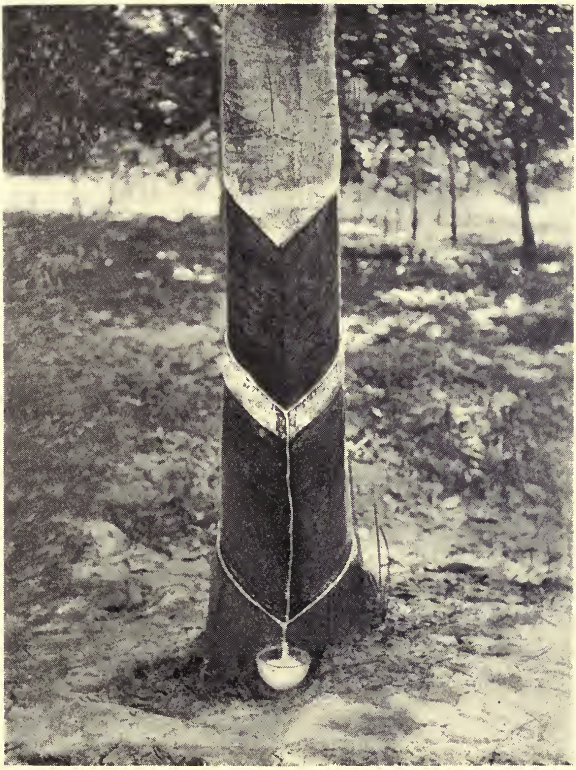

FIG. 39.—Tapping by Broad V System, but with Two Cuts.

Where Mr Gallagher gets his facts from is not known. Considerable experience of tapping tens of thousands of trees in Java, Sumatra and elsewhere directly contradicts his statements. The trees do not grow larger above the tapping cuts than they are lower down; at least such is the general experience.

It is not imperative that trees must sooner or later be divided into quarters. There are systems which do not involve this, although, perhaps, they were not known to Mr Gallagher at the time he gave his lecture and published his pamphlet. Such a system is described later on. It might also be added that instead of finding yields fall off after six months' tapping a considerable increase has resulted on many well-known estates where the basal V is regularly employed.

The half-spiral in the form of one single oblique cut across half the width of the tree is a good method by which to tap young trees for the first time. It is free from one objection which might be urged against basal V tapping, in so far that it does not involve both right and left-hand paring at the same visit, and is therefore more likely to be regularly and well done.

Later on the trees can be divided into sections, so as to secure a six or eight years' renewal for the bark cut away. The diagram given herewith will serve to illustrate how this is arrived at.

It will be seen that there is only one section allowed for each year's tapping. It is believed that this one section will give better results, with an every-day tapping, than paring on two, three, four or even five sections would yield. The reason for this statement is given fully a little further on.

The half-herring-bone system is at present the favourite system of tapping. Carefully executed, with a reasonable number of cuts, three or four, it can be so laid out as to allow for a four-years' period for bark-renewal. Every-day tapping, on one side of the tree only, is the soundest method and generally gives much the best returns.

Some contend that cuts on two sides of the tree, tapping on alternate days, is a system with at least equal merits; but this is obviously wrong. It interrupts the passage of plant-food through the bast over twice as large an area of bark. It is better to confine the interrupted area to as small a space as possible. For this reason it is better to confine tapping to one quarter-section of the tree, and the half-herring-bone in this way presents advantages over the full-herring-bone system.

The tapping results on two of the best-known estates in Sumatra are interesting. One tapped both sides of the trees every day, while on the other neighbouring estate two sides of

FIG. 40.—Marking Trees for Tapping.

the trees were tapped, but only on one side each alternate day. The yield per tree was the same in each case, but the second estate got its yield with only one-half the amount of bark excised which was thought necessary in the case of the first estate.

FIG. 41.—Tapping by Half-herring-bone, Quarter-section System, Four Cuts.

Tapping by means of spiral oblique cuts on a one-third section of the trees is a system very popular in Ceylon and not unknown in other countries. Each one-third section of the tree has to last for a year, and thereafter, if and when the tree has grown sufficiently, the tree is divided into quarter-sections. The dangers of using up the bark too quickly is much greater under this system than in quarter-section tapping on the half-herring-bone method. In the fourth year of tapping one would be inevitably tapping on renewed bark only three years old, and this does not commend itself to those who have seen how bark is too quickly used up, even with the usual number of cuts on a quarter-section of the trees.

The number of cuts, as stated, should be limited. Where, as in the Selangor district, one can often see from seven to eleven cuts on a tree streaming with fresh latex, it is obvious that such drastic paring away of the bark has got to be paid for later on.

It is very hard to convince most managers that they will get just as large returns of latex from two or three cuts on a tree as from nine or ten. Yet such is the case, and on account of the smaller area of bark excised the trees will make better growth. Managers are generally hard-working men, most anxious to do their best for their companies. It is not because they are wasteful or extravagant that they pare away the bark so severely. It is simply and solely on account of their anxiety to get big returns. There is a spirit of competition in this matter. The monthly returns of each estate are always published, and if the amount from any estate seems to lag behind from any cause, whether within the control of the manager or not, he naturally fears he will hear about it from his board.

On many estates, as has been stated, tapping has for some considerable time been far too severe. On well-known estates one can see, or could see very recently, from seven to eleven cuts on the bark of the trees, all freshly running with latex. Some managers have stated as their opinion that the more one cuts the more one gets, that the second-renewal bark yields better than the first, and the third-renewal bark better than the second.

On this merry principle of cut and come again a good many estates have been running gaily for some years past. Now there is a change in the tune. To the alarm of many managers the bark has refused to renew at all well. High tapping—a sure sign of mismanagement—has been had recourse to, till that device has also failed. One hears whispers of so many hundreds of acres being rested on this and that plantation, and those on the spot can sometimes see alternate rows in the areas in tapping being rested, so that the trees may have a chance to recover and the bark to again renew properly.

Estates which have only a limited area in bearing are often the most severely tapped. The reason is that there is more pressing need for returns in such cases to meet current expenses and, if possible, pay a small dividend. The manager feels the

FIG. 42.—Tapping a Young Tree, Half-herring-bone, Quarter-section System, Two Cuts.

necessity for getting as large returns as possible at almost any cost, and has always the hope before his eyes that when a larger area comes into bearing he may be able to ease off his tapping methods. Unfortunately this does not work out in practice. Large areas of bark having been cut away, bark having been re-tapped before the renewed bark is thoroughly matured, returns on the old areas show signs of falling off, which the younger areas, coming into bearing for the first time, do little more than make up for. Under such circumstances more severe tapping and high tapping, which is always bad tapping, have been freely indulged in. On many estates matters have in this way been approaching a crisis, and hundreds of acres have had to be rested on account of over-tapping on many of the best-known estates. This is a proof that a four years' bark-renewal period is not sufficient. Especially is this the case in closely-planted estates.

On one well-known closely-planted estate in the Federated Malay States the actual rubber contents of the latex from certain areas, as the result of long-continued over-tapping, fell on one occasion to as low a figure as 1 per cent., a sure proof that the trees were in a very bad condition.

On such estates, owing to there being no leaves on the lower branches of the trees, the trees therefore being dependent on a scanty crown of foliage, they have not been able to manufacture sufficient supplies of plant-food for proper bark-renewal and the natural growth of the trees. The roots of the trees also have been "cribbed, cabined and confined." Owing to the impossibility of cultivation, the soil, among such a tangled mass of roots, has become caked, dank and unaerated, and the bacteria, which ought to supply nitrogen in solution to the roots of the trees, have been unable to fulfil their function, as without proper supplies of oxygen they cannot breathe and work.

Drastic thinning-out of trees in the endeavour to secure light and air for better bark-renewal is in active process in many estates. Managers and visiting-agents have realized that much longer intervals must be allowed for complete bark-renewal.

The results of an interesting series of experiments, carried out by the well-known visiting-agent, Mr Skinner, on the West Country Estate, belonging to the Federated Malay States Rubber Company, Limited, are given opposite.

It will be seen that Mr Skinner experimented with (1) the full-herring-bone tapping on alternate days, giving four complete cuts (*i.e.*, eight units); (2) the basal V, daily tapping (two units); (3) the basal V, alternate-day tapping (two units); (4) single-cut tapping, alternate sides, daily (two units); (5)

TAPPING EXPERIMENTS ON WEST COUNTRY ESTATE SINCE COMMENCEMENT.

No.	Date	23-8-11 to 23-9-11		14-10-11 to 27-11-11		23-8-11 to 31-12-11		1-1-12 to 30-1-12		1-2-12 to 29-2-12		1-3-12 to 29-3-12		Totals	
	Nature of Tapping	Average per Tree	Average per Tree	Average per Tree	Average per Tree	Average per Tree	Average per Tree	Average per Tree	Average per Tree	Average per Tree	Average per Tree	Average per Tree	Average per Tree	Average per Tree	Average per Tree
1	4 cuts, Full H.B., Alt. (8 Units) . . .	.070	.009	.11	.01	.49	.061	.20	.025	.19	.024	Not taken		.900	.112
2	Basal V, Daily (2 Units)	.20	.10	.18	.09	1.20	.60	.29	.145	.28	.14	.29	.145	2.07	1.03
3	Basal V, Alt. (2 Units)	.040	.020	.34	.17	.36	.18	.12	.06	.11	.055	.11	.055	.707	.363
4	1 cut, Alt. sides, Daily (2 Units) . . .	.080	.040	.11	.05	.84	.42	.21	.105	.22	.11	.19	.095	1.47	.735
5	1 cut, Alt. sides, Alt. (2 Units) . . .	.030	.015	.34	.17	.32	.16	.11	.055	.11	.055	Not taken		.557	.278
6	2 cuts, Full H.B., Daily (4 Units) . . .	.19	.047	.11	.02	.952	.238	.23	.056	.24	.06	.20	.04	1.63	.407
7	2 cuts, Full H.B., Alt. (4 Units) . . .	.050	.012	.30	.07	.364	.091	.11	.027	.11	.027	.11	.027	.706	.176

one cut, alternate sides, alternate days (two units); (6) two cuts, full-herring-bone tapping, daily (four units); (7) two cuts, full-herring-bone, alternate-day tapping (four units).

If the table given herewith is carefully studied it will be seen that the fewer the number of cuts the higher the returns of latex. The best returns were given by the basal broad V, daily tapping. This is a result which will no doubt astonish many planters. The term basal V, though regularly used by estate managers and others, is not free from objection, since, in the course of continuous tapping, it may be moved up the stem some distance from the base. For this reason the term "broad V" is used in the text following instead of the term "basal V." The illustrations which are given here show how, by means of the broad V system, the bark of the tree can be divided up into sections so as to allow for six (or eight) years' renewal of bark.

While these results are most interesting, it is desirable that the experiments should be continued over a very much longer period. It is, however, gratifying to learn that the results to date on a number of estates confirm the figures given.

One objection to broad V tapping is that it involves right and left-hand paring, which is always troublesome. For this reason a single half-spiral cut might be preferable. It would probably yield quite as good returns of latex, and is a little less likely to interfere as much with the proper growth of the tree. This system is illustrated, and it will be seen that it also allows for a six (or eight) years' renewal of bark. On the suggestion of the writer it is at present being tried on well-known estates in the Federated Malay States and Sumatra, and results will be published later after a sufficient time has elapsed to admit of a fair trial.

A series of experiments recently carried out at the Government Experimental Station at Heneratgoda, Ceylon, give rather surprising results, which go to prove that as large a yield can be obtained from a tree tapped only once a week as from a similar tree tapped daily, or on alternate days, all through the week. These experiments, although at first sight very dissimilar to the ones narrated above, have this strong feature of resemblance, that they prove that as much latex can be obtained from a very moderate paring of the bark as from the most drastic cutting. In both cases an eight-year period for the thorough renewal of the bark is easily obtainable.

The following extract is from the circular describing the experiments:—

"The experiment described was carried out on seven rows of ten trees each. The trees are old and closely planted. The rows are numbered I. to VII., and tapping was carried out on

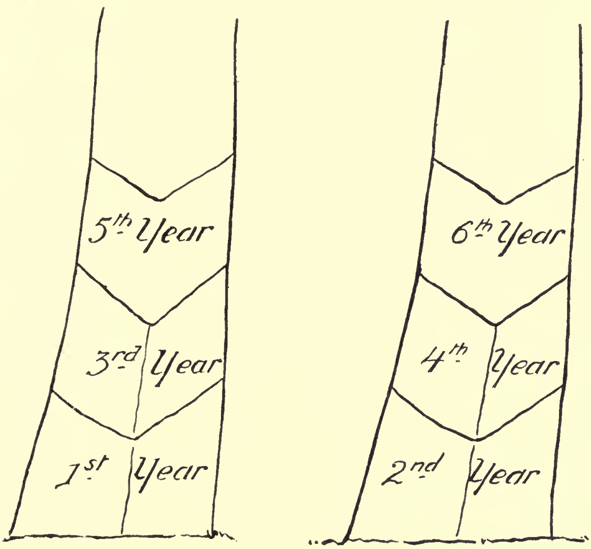

FIG. 43.—Broad V System of Tapping.

the system described in the circulars, in the same way on all the trees, except that the interval between successive tappings was different for the different rows. The following table shows the average interval in days between successive tappings, and the number of years allowed for renewal on the system adopted:—

	I.	II.	III.	IV.	V.	VI.	VII.	
Interval	1.4	2.6	3.9	5.1	6.5	7.8	9.0	days.
Period of renewal	2.3	4	6	7	8	9	10	years.

"The average yield per tapping of ten trees is given in grammes in the following table, which covers he last six months of 1908 and the whole of 1909, 1910, 1911. During the whole of this time the experiment was carried on without a break.

AVERAGE YIELD PER TAPPING.

	I.	II.	III.	IV.	V.	VI.	VII.
1908	100	107	148	158	169	210	163
1909	57	72	86	91	113	121	108
1910	58	69	67	96	118	115	115
1911		87	78	143	169	176	154

" One of the best-yielding trees in Row III. had, unfortunately, to be cut out early in 1910 owing to canker. No allowance is made for this fact in the above table, but in the table which follows one-fifth of the actual yield is added to the yield for Row III.

" It was obvious, early in 1910, that some of the weaker trees of Row I. had suffered from the rate at which they had been tapped, and it was not thought desirable to continue operations on the renewed bark.

" Now it might be thought possible to draw the conclusion at once from the above table that the yield of rubber per tapping increases directly with the interval between successive tappings up to an interval of eight days (Row VI.). But it has to be remembered that Row I. is always in a later stage of tapping than Row II., and so on; whilst, down to the end of 1910, the earlier tappings give, in all cases, higher yields than the latter ones. Towards the end of 1911; however, the yields began to increase. This increase was much greater in the case of the rows tapped at longer intervals. The following table shows the yields for January and February, 1912:—

PERIOD OF SIXTY DAYS, JANUARY AND FEBRUARY, 1912.
GROUPS OF TEN TREES.

(*Allowance is made for the fact that Row III. contains* 9 *trees only*.)

	II.	III.	IV.	V.	VI.	VII.
No. of tappings .	24	17	12	10	8	7
Total yield, grammes	1,932	1,540	2,080	2,163	2,020	1,572
Average per tapping	80	90	173	216	252	224

" The average yields from Rows V., VI. and VII. for these two months are greater than any yields previously obtained from Rows I., II. and III.

"From the above table the remarkable fact appears that, after three and a half years' steady tapping (making full allowance for the fact that Row III. contains only nine trees), Rows IV., V. and VII. each yielded a larger amount of actual rubber, from twelve, ten and eight tappings respectively, than Rows II. and III. from twenty-four and seventeen tappings respectively.

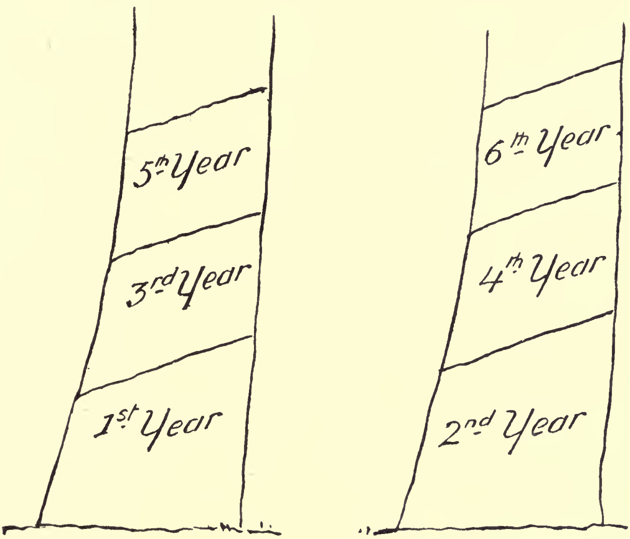

FIG. 44.—Single Half-spiral System of Tapping.

"Turning to the figures for 1909-11, it is of interest to record approximately the crop per acre which the yields recorded would produce. The result expressed in pounds is as follows:—

AVERAGE ANNUAL CROP PER ACRE.

	II.	III.	IV.	V.	VI.	VII.
1909-10	566	480	381	364	315	257
1911	653	620	605	565	490	360

"Now the yield for 1911 has increased over the average yield for 1909-10 in every case, but the increase is decidedly greater in the case of the rows tapped at longer intervals.

Expressed as percentages of the average yields for 1909-10 the increases are as follows:—

II.	III.	IV.	V.	VI.	VII.
17	29	59	55	56	38

" In view of the figures for January and February, 1912, the conclusion presents itself that we are rapidly approaching a period when the crop gathered once a week will exceed the crop gathered every three or four days. According to the figures so far available, an interval of six and a half days (Row V.) appears likely to give the best final result. All the tables here given show a distinct falling off in the case of Row VII., indicating, as might have been expected, that nine days is too long an interval. The best yield per tapping is given throughout by Row VI., and the best total yield for January and February, 1912, by Row V. To revert to the subject of the early part of this article, if these were the only facts available we should be justified in recommending a period of renewal of eight years as superior to one of four years."

The results have since been confirmed by continued tapping experiments.

As has been already stated, although the foregoing methods of tapping are very dissimilar to the single half-spiral cut recommended in this chapter and to the broad V cuts experimented on by Mr Skinner, yet while all of them are very sparing of the bark, the returns of latex are in excess of those obtained by ordinary tapping methods.

If further proof were needed to establish the fact that as good or, as is contended, greatly better yields of latex can be obtained by making less than half the number of cuts so commonly employed, it can be very readily forthcoming.

The best yield per acre on any estate in the East, so far as is known to the writer, namely, over 1200 lbs. per annum, is obtained on the well-known Pangkattan Estate, Sumatra, belonging to the Sumatra Para Rubber Company. This extraordinary yield is obtained from only three cuts on the half-herring-bone quarter-section system. These three cuts involve the paring away of rather more bark than would be cut away by the two right and left-hand cuts to form the broad V adopted by Mr Skinner or than would be shaved away by the half-spiral single cut before described. Yet it will be admitted to be very moderate tapping, and probably, if sufficient distance is allowed between the cuts, say eighteen inches, there is nothing better. In any case it seems abundantly evident that tapping has hitherto been generally on wrong lines. From every point of view—the health of the trees, the proper renewal of the bark, the best returns of latex, the lowest tapping-costs, the least labour involved and the securing of the largest proportion of first-grade latex rubber and the lowest possible proportion of bark-shaving rubber—such a system is to be recommended.

The feature which one notices about nearly all the tapping experiments recorded in the various volumes heretofore published is that they are quite inconclusive. They have been conducted on extremely limited numbers of trees for extremely limited periods of time. At least 500 trees should be simultaneously experimented upon for each system of tapping it is intended to contrast.

To take only about twenty trees, and to experiment with three or four systems of tapping for a week or a month, or two months at most, does not give any conclusive data. In such a small number of trees there are bound to be great inequality in the yields among the trees, while the number employed is too small to average down to a fair proportion. Everyone knows that among, say, twenty trees of fairly-advanced age there are some which are much better milkers than others. Such trees might well give better results with a wrong system of tapping than poorer trees with a better system, so that the results arrived at when experimenting with a very limited number of trees can scarcely be considered of any great value.

It is most desirable that some planter of standing, whose name would carry weight, should experiment for a period of at least six months—twelve months would be even better—with equal blocks of 500 or 1000 trees. He should try the broad V system, and the half-spiral, one cut. Against these he should try the half-herring-bone and the full-herring-bone with varying numbers of cuts, and any modification in the way of daily or weekly tapping that suggested itself. The total daily yields of latex for each set of 500 or 1000 trees should be carefully kept till the final total was arrived at. It would also be essential that the total amount of bark excised should be carefully calculated at the end of the period and the condition of the trees reported upon.

Such information would be of the very highest value, and would quite outweigh anything hitherto recorded.

If trees in tapping are not too widely scattered, a coolie ought to be able to overtake the tapping of from 250 to 300 trees per day. The number overtaken of course depends largely on the number of cuts the coolie has to make on each tree and whether tapping is on one side or both sides of the trunk. Sometimes the tappers have attendants to carry water, place the cups, and cleanse them and the spouts of any dirt, and this of course is a saving of time to the tapper and enables him to make more cuts. It is most usual, however, for tappers to work single-handed.

Scrupulous cleanliness should always be insisted on with regard to all vessels for containing latex, and in the factory itself, but all these precautions are, to a large extent, wasted if coolies are allowed to draw dirty water from ditches for the purposes of tapping operations. This is, unfortunately, far too common a practice, and is not only the means of introducing many impurities into the rubber, but is often the contributory cause of red spots and tackiness in the manufactured rubber. There is, however, no necessity to use water for tapping operations. It is a bad practice and should be abandoned. The use of water in tapping does not reduce the amount of scrap rubber, as very many imagine, but has quite the contrary effect. There is far more chance of fermentation and discoloration of the rubber when water is used than when it is not used.

Tapping-costs, inclusive of tools and utensils, should not exceed fivepence to sixpence per pound on a young estate with about 250 acres in bearing, and this ought to be reduced as more rubber comes in. On an excellently-managed estate in the Bila district in Sumatra the tapping-costs have recently been brought down to twopence farthing per pound, which is probably a record figure, and, of course, could only be achieved with a high yield of latex from each tree in tapping.

It is, however, not reasonable to conclude that a manager is inefficient because tapping-costs are high in initial stages. The cost of tapping utensils of all sorts, and the marking of trees, fall very heavily on the first and second year's working. Then there is also the fact to be borne in mind that, in some cases, the trees give very poor yields at the beginning. When trees are only yielding 2 to 2½ grammes of rubber the manager is sometimes blamed for high tapping-costs. If the trees were yielding six grammes he would be praised for having managed well, as the costs of tapping would amount to only about half as much on the yield.

In the Preanger district in Mid-Java, for example, trees give exceedingly poor returns on the first year's tapping, say about 2½ grammes, and tapping-costs are necessarily high. In the second year, however, the trees give excellent yields of about 6 grammes, and the tapping-costs fall to a low level. The merit or demerit, as the case may be, in such instances attaches to the trees, not to the manager. In Sumatra, on the other hand, trees generally yield exceedingly well from the commencement of tapping, and the same may be said to apply to the Federated Malay States, on well-kept estates.

A very foolish course to pursue, when trees have been too closely planted and bark is not renewing well, is to lop off a number of the lower branches of the trees so as to let in more light and air. In the circumstances described above the trees have too few branches and much too little foliage. Such a course as this one would think is self-condemned. Yet it is not uncommonly advised by some visiting-agents when they find that bark is renewing badly.

In his most interesting and valuable book, *The Physiology and Diseases of Hevea Brasiliensis,* Mr T. Petch makes some remarks on this subject. He says:

" The advice has been given that, in order to secure a good renewal of cortex, the sun should be allowed to have access to the stems, and that for this purpose the trees should be lopped if necessary. While there may conceivably be instances in which lopping, and consequent exposure of the stem to full sunlight, might be advisable, as, for example, in severe attacks of canker, it can certainly be said that, as a general practice, it would defeat the object desired. Renewal of the cortex is favoured by a damp atmosphere; it is said to be more rapid in the Federated Malay States than in Ceylon, probably because the latter has more decided dry seasons. Moreover, the sudden access of sunlight would certainly cause the renewing cortex to split, and the same might be expected to happen to the original cortex, if the trees had previously been heavily shaded. Because of the damper atmosphere among closely-planted Hevea, the renewal in such a plantation will be more rapid than if the trees had been widely planted. Here, however, another factor has to be considered, viz., the amount of food in the tree which is available for the formation of renewed cortex. The greater part of this food is stored in the tree before tapping begins, and the tree draws on this reserve to provide material for reconstruction. During tapping nothing is added to the stores behind the tapped areas; on the contrary, they are depleted. Now, the amount of food in a young Hevea is astonishingly large, and whether the trees are widely or closely planted it is quite sufficient to ensure the renewal of the cortex. Therefore, for the first renewal the two trees will be practically equal, as far as their food reserve is concerned, while the closer planted have the advantage of a damper atmosphere. The latter will therefore renew their cortex the more rapidly. In subsequent renewals, however, the advantage rests with the widely-planted trees. When the closely-planted trees grow up, their crowns interfere, and ultimately become mere bunches of leaves at the top of a long stem. A crown of this kind cannot manufacture an adequate supply of reserve food, and therefore the bark renewal must be slower. The influence of a damper atmosphere cannot compensate for lack of food. Lopping the trees, of course, diminishes the rate of manufacture of food still more."

While agreeing generally with Mr Petch's observations, it is very much to be doubted if, even in the first instances, the renewal of bark is quicker on young trees closely planted than when they are widely planted. By young trees one may presume are meant trees of five or six years of age, which have been tapped for the first time. The foliage of such trees, when closely planted, say 14 feet by 14 feet, or 17 feet by 17 feet, is already, at six years of age, seriously reduced. The under branches are, even at that early age, devoid of foliage and decaying. Under such circumstances, while there may be more dampness in the atmosphere outside the trees, the currents of food and water ascending the sap-wood and descending in the bark are feebler and less ample, and there is a smaller supply of building-up material available for bark-renewal. As will be seen, Mr Petch admits that later on, in any event, the advantage is all with widely-planted trees, and that is unquestionably a sound view.

The yields from trees vary very much, and the biggest trees are not always the best yielders. Sometimes a tree no bigger than its neighbours will yield twice or three times as much, and sometimes a tree which has been a good yielder will suddenly fall off. When a tree refuses to yield, or yields a very poor and reduced return, it is usually an indication that it is affected by disease and it should at once be very carefully examined. If there is no sign of disease and it is a persistently poor yielder it should be cut out and not allowed to encumber the ground. This should be done before the neighbouring trees cast too heavy a shadow and make successful replanting impossible. If, however, the trees round about are closely planted no replanting should be attempted, as the extra space will benefit the remaining trees by giving them more room for root expansion and increased space for their foliage to develop.

It is advisable that all estates should reserve a few acres of rubber trees untapped, till they arrive at an advanced age, for another and even more important reason. The seeds from untapped trees of advanced age have more vitality than those from trees which have constantly been tapped and too often severely tapped.

It might also be said that it is an excellent thing for estates to have reasonably large areas of unplanted land. These areas may later on become most valuable because, while the shade of old trees makes it impossible to supply vacancies caused by disease and storms of wind, one could look to having additional numbers of young trees planted, say 50 acres, each successive year to make up for any losses sustained. If these young plantings were from the seeds of old untapped trees one might expect the young trees to be of vigorous growth and more likely to withstand the attacks of disease than trees from weaker seeds.

It would appear to be almost unnecessary to state that the morning is the best time for tapping and that the earlier the work is started the better. All tools and utensils should be clean and in good order the night before, ready for an early start. Coolies' lines should be so distributed over the estate that no coolie has to walk a long distance to his work, and there should be always a muster and a roll-call on every well-managed estate, at each of which the manager or some responsible assistant should be present to check the roll. This is quite indispensable. Some managers think that if later in the day they check the coolies at work in the fields this is sufficient, but this is not the case. It is difficult to check the number of coolies at work at tapping, although it may be possible to do so at weeding, when there are gangs in the fields. To leave such work to mandoers, kanganies or headmen always leads to looseness, breaches of discipline, unpunctuality and want of efficiency.

A proper system should be laid down and strictly adhered to.

A tapper should not be given an undue number of trees to tap or the work is sure to suffer in quality. Besides this it has been found that when a tapper gets 450 or more trees to tap per day, with five or more cuts per tree, the yield per tree falls off.

On United Serdang Estates the number of trees tapped and scrap collected per coolie is 200. This may seem a small number, but it must be borne in mind in making comparisons that on many estates the practice is to give each tapping coolie an assistant—usually a woman—to rinse cups and collect the scrap. In this way a good tapping coolie is able to overtake a much larger number of trees, as good tappers are never too plentiful and are paid at a slightly higher rate; this is a sound and economical course to pursue. Then, again, in considering the number of trees which a coolie can efficiently work to the best advantage of the estate, it must be borne in mind that the system of tapping, and the number and the lengths of the parings made, have all a very direct bearing on the number of the trees the tapping coolie should be expected to overtake. So also has the planting distance. In ordinary circumstances, a coolie in the Federated Malay States is expected to make approximately one thousand cuts per day. Thus, if there are three cuts per tree he can attend to about 330 trees per day, whereas, if there are five cuts, 200 trees per day would be about his limit. Probably he might overtake a few more in the latter instance, as he would have less walking to do when attending to 200 trees than when attending to 300 trees, but the difference would be but slight.

Tapping-costs are, therefore, very materially affected by two factors in particular in addition to minor ones which might be mentioned. In the first place, the system of tapping adopted has a very direct influence. So far as results to date indicate, the single half-spiral cut is so expeditious and gives such good returns that it would appear to be the most economical in practice. Next in economy would come the single broad V, followed by three cuts on the quarter-section half-herring-bone system. In the second place, tapping-costs are swollen or reduced according to the number of trees tapped. If, owing to only a limited number of trees being in bearing, the trees are at irregular intervals and widely scattered, then costs are high. If, on account of insufficient or badly organized labour, only two hundred trees are tapped instead of three hundred as on a neighbouring estate, then tapping-costs are 50 per cent. higher in the one case than in the other.

The reasons why trees individually yield smaller returns of latex when a coolie is given too large a number to tap are twofold. In the first place, the tapping cannot, or at least will not, be so carefully done as if the number allotted to the coolie to tap was more moderate. It takes considerable skill and care to properly tap a Hevea tree, going in sufficiently deep to draw the laticiferous cells to the best advantage without at the same time causing any injury to the trees. When, therefore, the number of trees which the coolie has to tap, and the number of cuts he has to make, are too large, sufficient time and sufficient care are not bestowed on the operation, as the coolie is anxious to finish off his round. The tapping is not done so deeply because, although the coolie might be fined or punished for causing wounds while working in haste, he is not, as a rule, penalized on account of his tapping being a little shallower than it might.

In the second place, an obvious enough reason why the yields of latex per tree are reduced is because much of the tapping will, necessarily, have to be done when the day is well advanced and the heat of the sun has greatly increased. All planters are aware that latex flows best early in the morning and second best late in the afternoon, and that during the heat of the day yields are markedly reduced. It might also be added that in the case of trees tapped during the heat of the day the yields of first-quality latex fall to a minimum, as there is a lot of lump rubber formed by the spontaneous coagulation of the rubber in the cups and a greatly-increased proportion of scrap owing to the latex drying quickly in the channels before it reaches the cups. These are all matters of great importance, and the efficiency of the field practice, if not up to the mark, may render largely nugatory the efforts of a really good factory manager to raise to a high level the proportions of first-grade latex rubber turned out from the factory and very materially increase the proportions of the lower grades at the expense of the first quality. It is then the duty and ought to be the special care of a good manager to see that such matters are well regulated and that all sections of the estate work are carried out harmoniously to the best advantage.

These points, it is to be feared, are lost sight of by many really excellent hard-working managers. They are items, however, which cannot be neglected without the efficient working of estates suffering.

As already stated an assistant ought to be set apart to continually and vigilantly superintend the tapping on every 250 acres of rubber in bearing. This is the practice of several of the best estates. Two hundred and fifty acres are as much as one man can well superintend. Wherever a tree is found to be wounded it should be at once marked with a blue pencil, and the coolie who did the tapping should be warned for first offences and fined for any subsequent carelessness.

Yields of latex from Heveas are much heavier in the months of August, September, October, November, December and January than in any of the other months of the year. Thus, if a certain area in bearing is yielding at the rate of 5000 lbs. per month in April, May or June, it will be reasonable to expect an output of 7000 to 7500 lbs. per month from the same area in the later months of the year. The reason of this is not so much on account of any increased girth the trees may have attained, as from the fact that after the period of rest from the activities of growth during wintering and consequent recuperation the trees start off again with renewed vigour and vitality.

CHAPTER XXII

TAPPING-KNIVES AND UTENSILS

KNIVES.—Of tapping-knives it may be stated that their name is legion. It would be of no advantage to attempt to give a description of the great variety of ingenious contrivances, patented and unpatented, designed for the purpose of ensuring good tapping and lessening the possibility of wounds to the trees. Suffice it to state that, in this as in many other cases, the simplest tools are the best. The two most popular

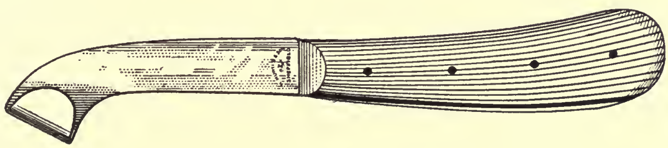

FIG. 45.—Jebong Knife.

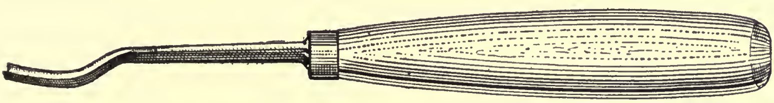

FIG. 46.—Bent Gouge used in Tapping.

tools for tapping, and probably the two best, are the ordinary gouge and the Jebong tapping-knife, and variations of these. Both of these tools are, of course, of the simplest description. They are inexpensive. There are no guides or screws to adjust, and therefore the simple man, though a coolie, need not err therein. Repairs are *nil ;* resharpening is easily done.

Among the well-known tapping-knives in use on many estates, and giving good results under skilled supervision, are the Bowman and Northway, the Sculfer, the Macadam-Miller, the Barrydo, the Burgess and the Reefer.

There are many other excellent knives, perhaps less known to fame but which do quite satisfactory work.

After all, it is largely a question of each man to his taste. Where coolies are found to be doing good work with any class of knife it is not wise to be too ready to introduce another type. Coolies, as is well known, do not like changes, and when they have been accustomed and trained up to execute good tapping with one class of knife, it is generally most inadvisable to make a change. If a change is made, the quality of the tapping is very apt to suffer for a considerable time.

The estate manager should insist on all tapping-knives being kept clean and brightly polished. On one well-known Java estate the manager has a long rack in the factory, with hooks upon which the tapping-knives are all hung up at the end of the day's work. Each hook is numbered, and above the numbers are labels with the name of the coolie who uses that particular tapping-knife. The knives are regularly inspected, and every pay-day the coolie whose knife has been kept the cleanest and brightest receives a small bonus. The system is found to work well. Tapping-knives should be inspected regularly, to ensure that the edges of the blades are kept sharp. If knives are blunt, fine tapping work cannot be done, and the surface where the parings are taken off is dragged and broken.

Cups.—Coconut shells should never be used as receptacles for receiving the latex, as it is impossible to keep them clean. Wherever used they are invariably found to be in a very dirty condition. If latex accumulates impurities at such an early stage of the proceedings as tapping, it is extremely difficult to turn out a first-class quality of rubber from the factory. Tinned iron cups have gone out of fashion, as it was found that they always got rusty and discoloured the latex. Enamelled iron cups are also objectionable, as the enamel chips off and rusty spots appear. They are also heavy and sometimes expensive. Glass cups are very generally used all over the East. Nowadays they are generally made with lemon-shaped bottoms, so that they will not stand upright on a flat surface. When at first introduced these were made with flat bottoms, but it was found that they disappeared from the estates in thousands, as they supplied a felt want in the coolie-lines and elsewhere, serving to make up the deficiencies in domestic crockery. When they were made lemon-shaped, and with the name of the estate generally stamped on them, the demand for such purposes fell off visibly and the situation was saved. Glass cups should always be of clear glass, not red or green, as in such cases it is not so easy to see that they are kept thoroughly clean as when they are made of clear glass. The chief objection to the use of glass cups is that they crack and split readily into fragments under the glare of the strong tropical sun. In every estate where they are of general use broken cups are to be seen lying round the foot of the trees, and unless gathered up from time to time, and buried deeply, they are apt to inflict nasty wounds on the bare feet of the coolies.

Porcelain (earthenware) cups, cheaply supplied from China and Japan, are also used on many estates. They are easily kept clean and do not crack so readily in the sun.

Aluminium cups have recently come into favour. The first cost is higher than that of other cups, but they are unbreakable, rustless, easily cleaned, and, as they are very light, freight charges are lower.

Whatever description of cup is in use, the cups should always be kept scrupulously clean. Managers should never allow them to be laid on the ground at the foot of the trees. When this is done, dust is apt to blow into them, and with every shower of rain they get spattered with mud. Many managers have short sticks in the ground, and the cups are deposited upon these upside down. These sticks, however, are constantly decaying and breaking, and as every piece of dead wood upon an estate, no matter how small, may be a source of fungal disease, this is not an advisable method, although much better than laying the cups on the ground. Some managers have large nails driven into the trees, on which they suspend the cups; but this course is not free from objection, as the nails cause wounds in the trees. The best way is certainly to deposit the cups in wire hangers. These can be supplied by any large estate-agency house.

Spouts.—Spouts are usually made of zinc or galvanized iron. They should be of sufficient thickness and strength to enable them to be pressed into the bark of the trees without bending or doubling up. It has sometimes been the case that a consignment of spouts has proved useless, as the spouts were too thin, and the metal of which they were composed too soft, to stand pressure into the bark of the tree without doubling up. It is essential that all the spouts on the trees on the estate should be kept clean. Nothing is more common on going over an estate than to see dirty spouts everywhere.

Buckets.—The buckets into which the contents of the latex cups are emptied should preferably have covers, with a flap which easily lifts up and down, so that, while there is ready access to the inside of the bucket, the sunlight is excluded. Needless to say, the buckets should be carefully scoured out every day in the factory. It is of little consequence whether the buckets are made of zinc or enamelled iron, provided that they are always kept clean, never allowed to become rusty, and are not too heavy for the coolies to carry easily when they are filled with latex. Sometimes very heavy receptacles, similar to the large dairy-cans in which milk is dispatched from the country to big cities, have been sent out to estates. These have proved much too heavy, when filled with latex, for coolies to transport with convenience. Covered buckets are better.

Latex Carriers.—On fairly extensive estates with many rubber trees in bearing, carrier carts, mounted on wheels, are a great convenience for the conveyance of latex to the factory. Where latex is coagulated at outlying sheds these carrier carts are useful for transporting the coagulated rubber to the factory without exposing it to the sunlight. These carriers can either be pushed by hand or be obtained in larger sizes suitable for ox-haulage.

Light Railways.—In cases of very large estates, or where two or more estates belonging to the same company adjoin each other, light railways for the transport of latex, goods and materials are of the utmost use. What is known as the Decauville system is the most easily laid down, and, generally, the least expensive. The railway simply consists of two rails screwed down to light iron sleepers. All that has to be done is to deposit the sleepers on the ground, at distances of about a couple of yards from each other, and screw down the rails to adjustable brackets with iron bolts. These railways are extremely common in Sumatra, especially on tobacco estates,

FIG. 47.—Coolies bringing Latex into the Factory.

which are very large, and where ground is left fallow for a number of years after cultivation. There the convenience of having a railway system which can be laid down or lifted up by a few coolies is much appreciated.

The mono-rail system consists of a single rail along which light cars are run. The cars are balanced by coolies running alongside, and guard wheels on which they may rest prevent them from overturning. The first cost for the rails is somewhat cheaper, but is somewhat discounted by the necessity for special cars, and, unless loads are very light, by the difficulty in balancing. The system, however, is in use in many lands and must be found to have advantages.

In hilly country, or where there are rivers or ravines to be crossed, wire-rope carriers are very useful, simple to work, and by no means high in cost. These are employed for a great variety of purposes in nearly every country in the world. For the conveyance of latex from hillsides to factories there is nothing equally as good. Working expenses are practically *nil*.

CHAPTER XXIII

MOTIVE POWER

THE choice of motive power is one which deserves careful consideration. Suction-gas engines give a cheap and efficient motive power; but on most estates timber for charcoal is soon exhausted and coal not readily obtainable at a reasonable price.

Where cheap coal can be regularly obtained the suction-gas engine can hold its own against oil-fuel engines.

Oil fuel is abundant everywhere. Oil-engines are easily managed safely and kept clean without dust or difficulty. Hence they are in general favour in factories and rubber plantations. Among the cheaper makes the Hornsby oil-engine is one of the very best and seldom gets out of order. Instead of putting down, for example, one large engine of say 70 h.p., it is more economical, as well as more advantageous, to lay down two engines of 35 h.p. each. The additional cost is but slight. The engines are lighter and more easily transported to the estate. Should only three or four machines be running, only one engine need be in operation. If a breakdown occurs from any cause there is always one engine in working order, and factory operations are not seriously interrupted. The Diesel oil-engine costs considerably more than most other makes, but it is exceedingly economical in its consumption of liquid fuel, a 50-h.p. engine being guaranteed not to consume more than one half-pound of liquid fuel per horsepower per hour. A 50-h.p. engine thus runs with a full load at a cost of about 25 dollar cents per hour.

It is always most desirable to have a good margin of motive power over what is thought to be essential for the driving of machinery. Engines do not always develop power with full efficiency. Cases have come under personal observation where a 32 horse-power engine was unable to drive three mills at anything like a proper speed. For mills with rolls 12" × 16", 12 horse-power for each mill is not too much to allow, especially if one takes into account the invariable loss of power in gearing and belting. Then, also, one must take into account the class of rubber which is being manufactured. If one puts into the mills old scrap or similar tough old rubber it immediately acts like a brake on the mills, which demand several horse-power additional to perform their task. For many reasons a good margin of horse-power is strictly necessary.

Of all motive powers, the cheapest, the simplest and the best is a water-driven turbine, when an ample supply of water power is always available. There are large factories driven by such power both in Java and Sumatra. The cost of the turbines is exceedingly low, and the chief outlay is usually incurred in constructing the channel to convey the water from the river to the turbine. No attendance is needed and the cost per h.p. per hour is practically *nil*. Provided there is a sufficient supply of water, all that is necessary is to secure a good fall from the water-channel on to the turbine in order to develop a high horse-power. The smaller the flow of water the greater must be the descent of the water. The ordinary old-fashioned water-wheels give a very low horse-power as compared with turbines, as in their case only the weight of the water in the buckets is transformed into power and not the velocity of descent.

CHAPTER XXIV

MACHINERY AND MANUFACTURE

MACHINERY and processes of manufacture are often considered as merely mechanical routine. Many of those who are inspired by what has been called " the miracle of spring," when Nature wakes to new life, or who find much material for philosophic thought stirred by the fall of the once fresh and verdant leaf and its subsequent decay, find no room for philosophy or for poetic musings in the formalities of a factory.

True it is that Kipling could see farther than this. In MacAndrew's hymn the Scottish engineer describes in these vivid verses how pinions, cranks and shafts rise and fall in unison, working out in harmony the immutable decrees of fate.

Nature is *not* shut out of doors when the factory is entered. Here also the true shekinah may be found. Here, to the thoughtful mind, is marvel upon marvel. Just as in the ancient annals, when the prophet prayed that the eyes of his anxious and timid servant might be opened and the servant saw that he and his master were surrounded by a guard of horsemen and chariots of fire, so if the eyes of the assistant in the factory were enlightened he would see that he was face to face with forces little comprehended.

Let such an assistant consider a few—a few only—of the facts in front of him. He casts a careless eye upon the iron rubber washing-mill in front of him. He sees it. Why does he see it? Because the particles of which it is composed vibrate at not less than four hundred billion times a second. Did they vibrate at a slower rate he could not see the mill. Did they vibrate at a rate more than twice as fast the mill would again be invisible. Here have been at once raised a legion of the hows and whys which occupy the constant attention of the greatest scientific minds of the century.

Next let the assistant we have supposed have his attention aroused in this way to consider—What is matter? Again the door is opened to a myriad of most essential questioning. Admittedly iron is an element—one of the seventy-eight at present acknowledged to exist—but an element is not now recognized as the end of the alley past which one could no further proceed. Rather it is just the turning which opens up a new and apparently endless vista where one has divided down an element to the smallest possible particle that is called an atom. What is an atom? It is not a simple powdered particle to be viewed with a microscope. It is again a structure. The most complicated steam engine is a very simple structure compared with an atom.

The atom is not the ultimate. Sir Oliver Lodge has stated that if an atom could be magnified to the size of a fairly large building, such as a church, for example, the corpuscles of which it is composed would be represented by, say, some one thousand grains of sand. If the atom is heated these corpuscles would dash about at a speed of many thousands of miles a second. They repel each other, attract each other, and fly furiously around within the orbit of the atom.

What fills the space between the corpuscles—for there can be no vacuums in Nature? What exists beyond the corpuscles —mystery beyond microscopes? Men of science nowadays begin to whisper, Mind is—must be—behind.

Thus an intelligent assistant can inspire his daily task. He can—he ought to perceive that he is in a fairy kingdom where all that appears most real is most illusory.

Speaking of knowledge of this description, the Hon. A. J. Balfour, in his presidential address before the British Association, said: " It excites feelings of the most acute intellectual gratification. The satisfaction it gives is almost æsthetic in its intensity and quality. We feel the same sort of pleasurable shock as when, from the crest of some melancholy pass, we first see far below us the sudden glory of plain, river and of mountain."

To have one's intelligence aroused is no little thing in itself. An awakened interest in science is often the salvation of a lonely man on a plantation, establishing and preserving a sound mind in a sound body and ever making for a greater all-round efficiency of both. Hence no apology should be necessary for introducing the foregoing remarks.

The manufacturing of the coagulated latex involves a very severe strain on the washing-mills, and this is to some extent indicated by the fact that, although they are comparatively small in size, it takes about 9 to 10 horse-power to drive them when rolling sheets of crêpe. It is necessary, therefore, that the mills be of very solid construction, or they would soon give way. British engineers may not be so clever in devising ingenious labour-saving machinery as our American cousins, but they build strong to last long, a merit American engineers cannot so generally claim. A good width of rollers is a great advantage, and 18 in. by 12 in. is a good size. Wide rollers are advantageous in that more rubber can be manufactured during working hours, and there is also much less likelihood of any oil from the bearings getting into the rubber being rolled. By means of various patented adjustments the space between the rollers is easily increased or diminished without being greater or less at one side of the rollers than it is at the other side.

The difference between the speed at which the two rollers in the mills revolve can be too great or too little. The greater it is, the greater is the violence with which shredding and tearing the sheets of rubber proceeds. Experience has enabled engineers to arrive at a reasonable adjustment in this respect.

Rollers for macerating and crêping mills should have their patterns or grooves at least $\frac{1}{8}$th of an inch deep. This is the absolute minimum depth; $\frac{3}{16}$ths of an inch is by no means too deep. Now, it is very expensive work to cut these patterns or grooves. The metal of the rollers is so very hard that a file makes almost no impression. Evidently, then, the less the depth an engineering firm has to cut out these rollers to, the more money it will save. In several instances rollers have therefore been sent out to estates in the East cut out to a depth of only $\frac{1}{16}$th of an inch. These have been dispatched by more than one leading firm of engineers. Such rollers are practically useless. If any manager receives such he should refuse delivery right away. Owing to the shallow depth when the patterns on rollers are only $\frac{1}{16}$th of an inch deep, they cannot do their work properly. Instead of tearing, shredding and crêping the sheets of rubber, and at the same time properly cleansing it, the rollers act as sheeters, as on the finishing mills. As stated before, $\frac{1}{8}$th of an inch is the minimum depth of cutting that should be accepted, but $\frac{3}{16}$ths is better and allows for some wearing away of surface which a cutting of $\frac{1}{8}$th of an inch does not do.

It should not be necessary to state that in planning the factory, mills should be laid down with the front of the rollers facing the coagulating department. Yet cases have occurred where the mills have been so laid that the coolies have to pass round to the back with the lumps of coagulated latex for feeding the machines. This, of course, involved lifting the mills and laying down fresh foundations.

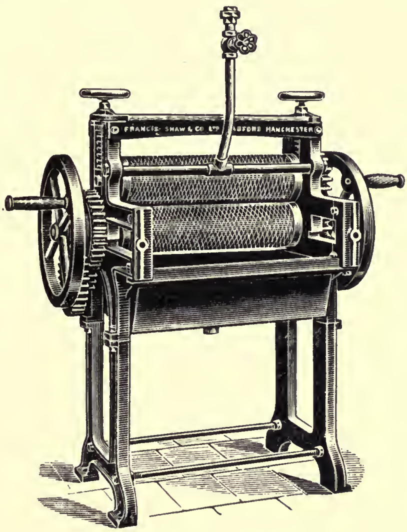

FIG. 48.—Shaw's Hand-driven Machine. Rollers changeable from Vertical to Horizontal Position.

Owing to the strain on the mills during working operations they require very solid cement foundations. The cement should be of the best quality or it will crack in places and work loose, and the mills will rock and grind away their bushes. Carelessness in such respects means early and frequent repairs, breakdowns and general disorganization. A manager may be a hard-working man with a thorough knowledge of cultivation and yet not have any experience of engineering. If, therefore, the factory is not to be fitted up and the machines erected and started by competent engineers, the plans and details sent out for his guidance should be clearly drawn out and complete in all respects.

In laying down rubber-mills they should be put down in the order in which the work ought to progress. In a factory the latex ought to enter from the plantation at one door and leave by another door leading to the drying-shed, having passed in proper sequence through the mills. No rubber should leave the factory except through the door leading to the drying-shed and packing-house. Proper regulations of this sort assist in keeping down petty pilferings of the manufactured rubber, of which far more often goes on than managers are aware of. In Ceylon, the Federated Malay States and Sumatra there are nearly always dishonest dealers in the villages who are ready to bribe the coolies to steal rubber if carelessness affords opportunities.

The rough macerating-mill should be nearest the door at which the latex enters. This is for two reasons. In the first place, latex, lump-rubber, scrap and bark-shavings are always treated first in this mill, and carriage is saved by having it at this end of the factory, which is also where the straining and coagulating of the latex should be done. In the second place, this rough macerator, with its deep-grooved rollers, is the mill in which scrap and bark-shavings are worked up, and there is always a lot of dirt in these which is best kept away from the better-quality rubber. Dirty rubber such as these grades should always be worked up at the close of the day's proceedings, on account of the amount of dirt brought into the factory embedded in such rubber and thrown out by the rollers of the macerator when the springy masses of rubber are stretched springing out in passing between the rollers revolving at different speeds. Some planters, for this reason, prefer to keep the macerator quite apart from the other mills, either boarded off or outside the factory, but such a course is neither necessary nor yet convenient.

When it is proposed to make sheets of crêpe-rubber the lumps of coagulated rubber are first treated in the macerating-mill. This mill converts the unshapely lumps of coagulated latex into thick, rough sheets. In the course of the rolling between the rough-cut, grooved-pattern rollers revolving at different speeds (usually a gearing of 18 teeth in one roller and 22 teeth on the other or 17 teeth to 21 teeth), there is a tearing and shredding of the mass, on which water is being constantly poured from a pipe over the rollers. This washing and shredding removes not only dirt but much of the protein and non-rubber matter originally contained in the latex and gradually transforms the cheesy mass into rough sheets of wet rubber. These protein and starchy substances, if left in the rubber, would be apt to ferment and develop tackiness, and are therefore best removed from rubber which is not intended to be smoked.

It should be understood, however, that this removal involves an appreciable reduction in the ultimate weight of the product obtained. In the manufacture of sheets for smoking the loss is not nearly so great. It might surprise some managers if they realized what the total difference amounted

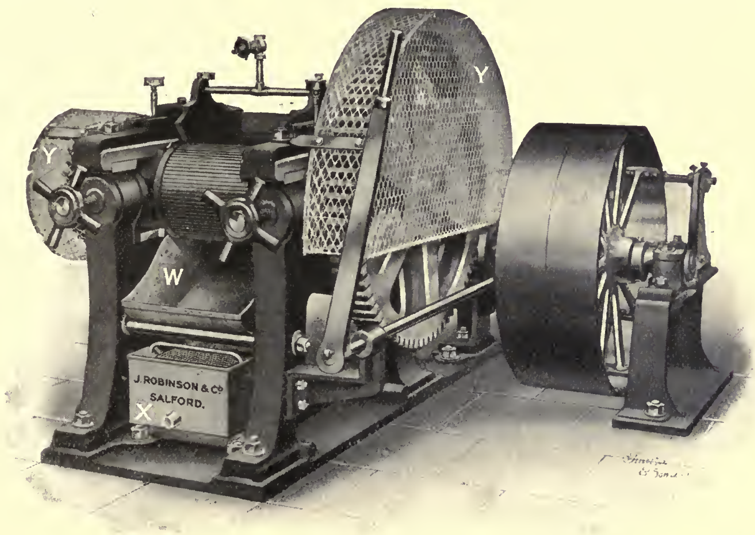

FIG. 49.—Robinson's Washing-mill, Belt-driven.

to in the course of a year. If we take it at 1 per cent. we shall not be very far astray, and with rubber at four shillings and twopence per pound the difference is equal to one halfpenny per pound. To look at it in another way, if the annual crop of rubber is two hundred thousand pounds, the 1 per cent. loss or gain is equivalent to two thousand pounds of dry rubber per annum at least.

The usual practice is to pass the coagulated latex three times through this macerating-mill before removing the rough sheets to the crêping-mill. This crêper is also a macerator type of mill, but the cutting on the rollers is on a smaller pattern.

The teeth on one roller being 18 and on the other 20, the shredding and tearing is less violent than in the macerator. In this, as in all the mills, water flows on to the sheets of rubber from pipes which discharge their flow of water from overhead on the rubber passing through the rollers.

This mill, fitted with adjustable screws, presses the rough sheets thinner, making them more compact each time they pass

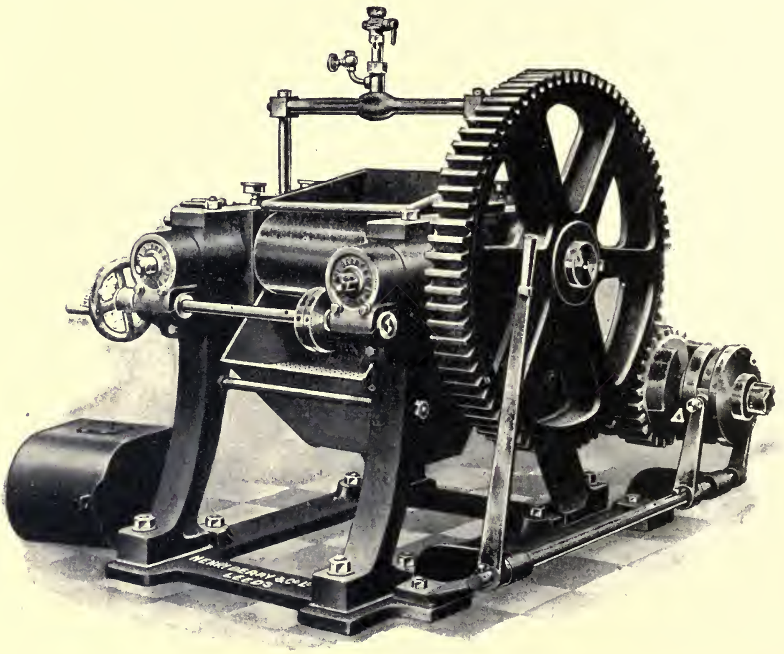

FIG. 50.—A Claw-clutch-driven Mill (H. Berry & Co., Leeds).

through. After they have been run through two or three times as single sheets they are doubled over on themselves so as to fill up any holes and are run through in this fashion other two times.

The mill on which the crêpe is finished has usually smooth rollers, or rollers with a slight grain or shallow groove on them. There is only one tooth of difference on the gearing of the two rollers. The crêpe should be passed through this mill twice or thrice, each time adjusting the screws so as to bring the rollers closer together and press the sheets of rubber into a very compact web of lace-like rubber with as few holes in it as possible. The smooth, chilled rollers generally supplied are too much polished and do not grip the sheets of rubber properly, and complaints are made that the rubber "jumps." The action of these rollers is too much that of polishing the rubber. Hard, cast-iron rollers, owing to the slight grain on them, are said to grip the rubber much better in this mill, and are much more effective in pressing the crêpe, so that small holes are filled up. In practice it is found that with such rollers the crêpe can be finished by passing them through four or five times, whereas with polished rollers the crêpe has to be passed through seven times, and the final result is not so good, the crêpe having more small holes left in it. The result of careful observations on Kuala Lumpur, Langkat Sumatra and other estates go to establish this fact, although it is disputed by some others. Chilled rollers are harder than hard cast-iron ones, and therefore wear longer, and are thought to resist the action of any superfluous acid in the coagulated latex rather better. As, however, of recent years more care is being taken to add a smaller excess of acetic acid to effect a complete coagulation than was formerly the case, complaints on this score are of rare occurrence nowadays. The cost of chilled-steel rollers, 18 in. by 12 in., is about £6 higher than of what are known as hard-cast or hard-grain rollers. This higher price quite discounts the saving of the, presumably, longer life of the chilled rollers.

Lump-rubber, by which is meant the lumps of rubber self-coagulated in the latex cans, passes through the same mills in the same sequence as crêpe-rubber.

Sheet-rubber for smoking is usually simply coagulated and run through a mill with plain or slightly-grooved rollers. This process, while pressing the coagulated rubber from a wet, spongy mass into sheets, does not subject it to the severe shredding, tearing and washing that crêpe-rubber undergoes, and the sheet-rubber therefore retains a lot of the protein elements originally present in the latex, which are more or less liable to set up fermentation actions. It is for this reason that sheet-rubber is usually smoked, smoke being of an antiseptic character.

One of the latest types of machine is the "Angle" roller crêping machine, belt-driven, a type popular in Ceylon. One of the objects in making the machine on the angle is to bring the front roller nearer the ground and allow of larger rollers being used. We would here mention that there is a tendency to increase the diameters of rollers on these machines, In the early days 9″ × 18″ was the standard in the Federated Malay States; then came the 12″ × 15″, and recently orders have been placed for machines with rollers 14″ × 24″. The larger machines naturally take more power to drive, but they do more work and

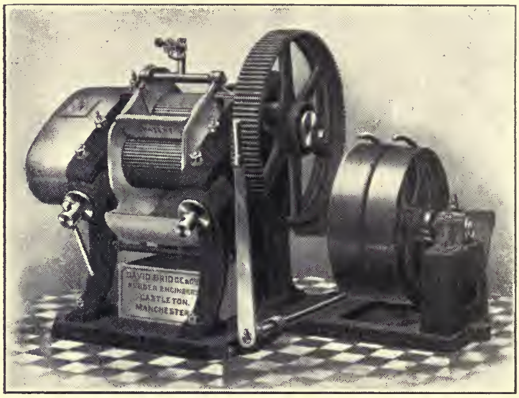

FIG. 51.—Bridge's Patent "Angle" Roller Mill.

the rollers last much longer. It may strike the reader that the idea of increasing the diameter of the roll is to increase the peripheral speed, but this is not so; there is a limit to the peripheral speed of rollers in washing, sheeting and crêping. The end wheels are of the usual friction speed which varies with the method of treating the rubber. These belt-driven machines are principally used in Ceylon, and here we may remark that there they are not quite up to the Federated Malay States level in engineering ideas.

The machine type J.A. is a standard type of machine for the Federated Malay States driven by machine-cut gearing and friction-clutch driven direct from the main-line shafting at the back of the machine. This machine is self-contained, all the brackets relating to the clutch-drive being attached to the bed-plate of the machine.

Very great improvements have been made regarding the quietness of running. In the early days ordinary straight-moulded driving-wheels were used, and then double helical machine-moulded, and now straight-cut or double helical machine-cut gears are quite the fashion. They are more expensive, but they run very quietly and wear very well. The speed of the back shafting of these machines is generally from 75 to 100 revolutions per minute.

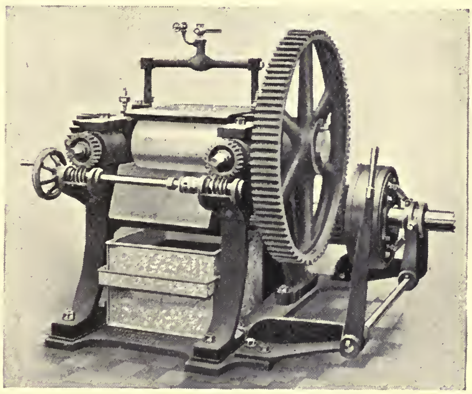

FIG. 52.—A Mill—Type J.A.—driven by Gearing with Friction-clutch (Bridge & Co.).

If the rubber is intended to be sent to the market in the form of block-rubber, such as is manufactured on the famous Lanadron estates, the sheets, after they come from the drier, are put one on the top of another till a sufficient number—as shown by experience — are assembled together in a blocking-press. These presses can be either hand-screw presses or, better, worked by means of hydraulic or other power. Under heavy pressure the sheets are compressed together into one homogeneous block. This form of rubber has much to commend it. It exposes the smallest possible area for dust or moisture to gather on, and the whole interior of the mass is retained in perfect condition. The only objection which has been raised to this form of rubber was the large size of the blocks in which the rubber was at first sent to the market. This, however, is a matter which is being adjusted.

Worm-rubber and strip-rubber are simply sheets of freshly-coagulated rubber cut into either small pieces or strips by cutting-machines with revolving blades, in order to ensure more rapid drying. After the strips have been dried they are usually again rolled into sheets. While quicker drying is doubtless obtained by such methods, there is more handling of the rubber, and with the sufficiently-rapid methods of drying now in general use the cutting-up of the rubber into small pieces seems unnecessary.

In some large factories—where there is a big output of rubber—scrap-rubber, cup-washings, bark-shavings, and sometimes even earth-rubber, are in course of treatment eventually massed together, finished off together, and sent out as second or third-grade rubber. Scrap-rubber is the latex which has coagulated on the trees without reaching the latex cups. Cup-washings are the rinsings of the latex cups. Bark-shavings are the fine shavings of bark cut off in the paring away of bark during tapping, and which are, or should be, always carefully collected by the tappers on account of the dried rubber contained in them. Earth-rubber is latex which has been spilled on the ground, and is, of course, a very dirty rubber. In treating such low-grade rubber the first endeavour should be always to get rid of as much of the dirt as possible as a preliminary operation and to pick out any stones.

Where the output of rubber is not very large and there is no " Universal " washing-machine, a good method for getting rid of such objectionable matter is that employed on Bangoen Poerba Estate, belonging to the United Sumatra Rubber Company, Limited. In front of the factory are a number of cement troughs, into which scrap-rubber, bark-shavings and earth-rubber are thrown. A volume of water pours down on the contents of the troughs from overhead pipes, and coolies give the mass a good stirring round. In this way a very large proportion of the dirt is got rid of, and much time and labour are saved when subsequently passing the material through the rollers of the macerator-mill. A strainer at the end of the last trough catches any light fragments of rubber or small pieces of bark swept away by the water. Quite a considerable amount of rubber is saved by this precaution. In the case of the Bangoen Poerba Estate it amounted to 120 lbs. of dry rubber per month.

Where there is anything like a large output of rubber a Werner & Pfleiderer " Universal " washing-machine should be installed. The scrap, bark-shavings and earth-rubber should be first passed twice through the macerator and then through the "Universal" washing-machine. In this way a very thorough cleansing is ensured. If put through the washing-machine first a lot of dirt remains in the rubber, as while the rollers of the macerator can tear up the rubber and release the embedded dirt the washing-machine cannot do this effectively. On the other hand, the washing-machine, in addition to the macerator, removes a great deal of dirt which would be still left in the rubber unless it were laboriously put through the macerator an impossible number of times. Scrap and other rubbers treated in this way fetch a good price, which amply repays the additional labour spent on them.

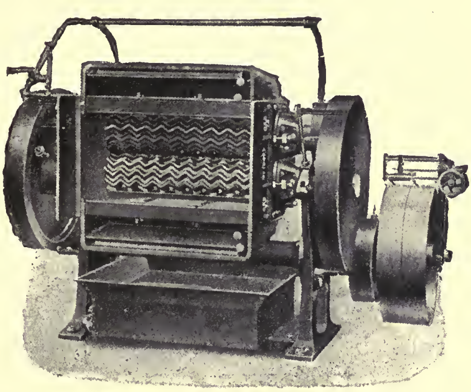

FIG. 53.—The "Universal" Washing-machine, with Trough and Rollers tilted.

A number of well-informed people take the view that if it were not for the requirements of scrap-rubber, bark-shavings and earth-rubber, it is probable that in a year or two we should find only finisher-mills in the factory to prepare sheets for smoking. The future factory, it is thought, may have no crêping mills, and a change of this sort may very well come about.

The question of how best to grade the rubber deserves very careful consideration by rubber-growers. Practice varies a good deal in regard to this matter. Some have advocated as many as five grades of rubber, namely, first-latex, lump-rubber, scrap-rubber—inclusive of the cup-washings—bark-shavings and earth-rubber. This is quite too long a list and the quantities of some of these would be quite small and troublesome to keep apart.

Generally speaking three grades should be quite sufficient for all purposes. Certainly the strained latex should be the standard for first-grade rubber. If the lump-rubber, after it is thoroughly washed and rolled out, is found to closely correspond in appearance with the first-latex, then the sheets may be added in among the first quality. Unless, however, the lump-rubber sheets are found to be quite equal in quality and appearance, which will rarely be the case, they should on no account be added to first-quality rubber. The quantity of this rubber as a rule is not—and should not be—great, and might, if added to first-latex quality, if it was inferior, drag down the standard and diminish the price obtained for the whole, thus involving a far greater loss than if kept as a second grade, or even added to the scrap-rubber quality.

While there may be some dispute as to whether lump-rubber should, or should not, be in a first or second grade, there should be no question but that scrap-rubber, cup-washings and bark-shavings should be ultimately united to form a secondary grade. They ought not to be united at first. The bark-shavings are better to be first steeped by themselves, and, when softened, ground up in the macerator to get rid of most of the bark itself. The scrap-rubber should also be separately passed through the macerator twice. Thereafter, if there is a "Universal" washing-machine in the factory — and no large factory should be without one — the two can be united in the washing-machine and freed from nearly all remaining dirt, preparatory to being sent down again to go through the mills and emerge finally as either second or third grade, as the case may be.

The earth-rubber is usually so exceedingly dirty that it is better kept apart and considered as a low-grade rubber. Even when treated in a "Universal" washing-machine it is more than doubtful that it does not lower the quality of other grades if mixed with them.

Whatever number of grades may be decided on, the great endeavour of the manager should be directed towards securing regularity of colour and, above all, of quality.

When manufacturing crêpe-rubber the manager's great effort should be to attain and maintain the highest possible percentage of first-latex rubber. To ascertain what progress is being made in this desirable direction, statistical sheets should be kept up-to-date in the estate office as well as by the secretaries at home. These sheets should show the weekly output of each grade of rubber and should be constantly referred to. The great effort should be to have as small a proportion as possible of what might have been first-grade rubber disqualified on account of discolouring or spots. This is where the greatest leakage is usually perceptible. To have a really high grade of first-latex rubber, discoloured sheets should be kept apart, or the standard of the whole lot will be degraded. The percentage of first-latex rubber has been claimed to be as high as

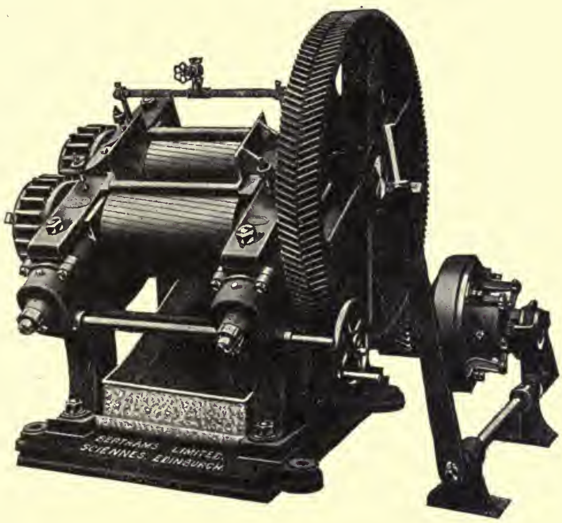

FIG. 54.—Washing and Crêping Mill, Large Angle Frame (Bertrams Limited).

from 75 to 80 per cent. on certain large, well-managed estates with well-equipped factories. This is indeed an excellent showing. In the case of the majority of estates it will be admitted that what is sent to the market as first-latex rubber is far from uniform. Out of fifteen cases there may be five which fetch—for example—4s. 4½d. per lb., five which realize 4s. 3d., and the remaining five 4s. 1½d. If all the cases had obtained the top price the total sum secured by the company would have been much increased. Uniformity in appearance and in quality is very essential. It is really then with the first-latex rubber that the great difficulties are experienced in endeavouring to secure absolute regularity without sacrificing a considerable proportion by reducing it a grade. This is a matter which is well worthy of care and attention from estate managers.

When well cleansed and well manufactured the second-grade rubber can—although of inferior colour—be brought up to quite a high degree of perfection, so that the prices realized are only a very few pence less than for first-grade. To secure as high a standard as possible for this grade of rubber is well worth striving for.

Scrap-rubber can be kept down to quite small proportions by good oversight in the tapping rounds. To save an undue number of grades the bark-shaving rubber might be amalgamated with this once it has been well worked up and cleansed and so might the cup-washings and skimmings.

Two factors affect the proportion of bark-shaving rubber. First, are the bark-shavings well collected? This, of course, should be seen to by the assistants superintending tapping. The second point, which has a very obvious bearing on the proportion of bark-shaving rubber, is the method of tapping employed and the number of cuts made. If on one estate there are only two cuts or three cuts made on the trees as against six, seven or more cuts made elsewhere to obtain a similar amount of latex, it is evident that the proportion of bark-shaving rubber is likely to be quite double in the latter case what it is in the former. It is not a matter over which good factory management has any control, yet it affects the relative proportions of all the grades of rubber to each other.

If one takes as a standard to work up to or excel the following proportions of each grade of rubber, one will not go far astray:—

First-latex rubber	80 per cent.
Second grade ,, ...	15 ,,
Third ,, ,, ...	5 ,,
	100 ,,

This is admittedly a very high standard to set and scarcely attainable by any but very large, well-organized establishments. On some other estates the division of grades and the proportions in practice are approximately as follows:—

First-latex rubber		75	per cent.
Second grade ,,	(lump-rubber)	5	,,
Third ,, ,,	(scrap-rubber)	10	,,
Fourth ,, ,,	(bark-shavings and cup-washings)	5	,,
Fifth ,, ,,	(earth-rubber)	5	,,
		100	,,

The objection to this is the manufacture and the keeping

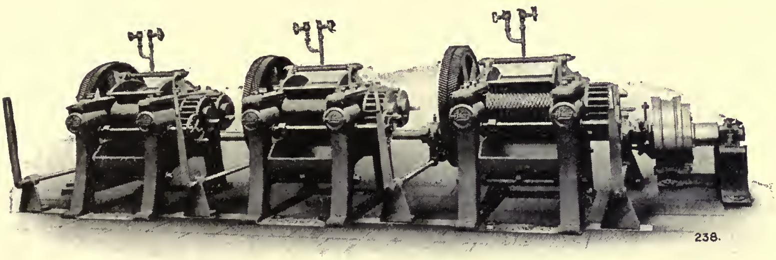

Fig. 55.—A Battery of Mills, Back-shaft-driven (Shaw & Co.)

separate and packing of so many grades, some of which must be quite small lots.

When rubber is smoked the smoking assists one in assembling in fewer groups the various grades, as slight differences in appearance are not so easily determined. This is a distinct advantage when grading rubber for packing.

After the thin sheets of crêpe-rubber have been hung up for a time, so that much of the water may drip off, they are sent to the drying-house or to the hot-air driers to be dried. When blanket-crêpe is desired the thin sheets of dried crêpe-rubber have to be slightly damped and several sheets compressed together by the rollers of the finishing-mill. This, of course, involves a subsequent further drying of the "blankets," as they cannot be packed wet. In some cases endeavours have been made to form the sheets of crêpe into blanket-crêpe without again wetting them, but a good deal of heat is evolved in the operation and the rubber is apt to be affected thereby.

It is very important to have at least one extra mill available in the case of breakdowns. Where and when the macerating, crêping and finishing-mills cannot be all duplicated, at least the crêper should be. The next in importance to duplicate is the macerator.

A spare pair of rollers ought always to be kept in stock in the storehouse for each type of mill. If there are two or more mills of a type such as the crêper in a large factory one spare pair will suffice for stock.

These spares should be kept thoroughly well greased and from time to time inspected to see that they are in a good state and not turning rusty. Having a spare pair may be the means of preventing very serious inconveniences in the case of accidents or from rollers wearing out and not doing their work properly.

Misunderstandings arise as to the output capacity of the mills from the fact that when an engineering firm states that a mill can turn out 300 lbs. of rubber daily, the fact is overlooked by some inexperienced people that the same 300 lbs. of rubber have to pass successively through the macerator, the crêper and the finisher. A battery of three mills—to which always should be added at least one extra to lighten work and as a stand-by in breakdowns—is capable of undertaking a yearly output of 250,000 lbs., working ten hours daily. This is really as much as such a plant is able to handle satisfactorily if the rubber is to be thoroughly washed and thoroughly rolled. In actual practice it is found that eighteen mills are quite severely enough taxed to get through an output of 1,350,000 lbs. per annum with one of the mills occasionally off for repairs. This is the experience of working year in year out of the best-equipped factories and may be taken as a safe guide.

It is no doubt the case that crêpe-rubber can be overworked in the washing-mills at the expense of much of its nerve and tensile strength. It is a well-known fact that molecular changes set in in a steel spring when it is "fatigued" by being too often bent, and the tearing and stretching to which crêpe is subjected in the washing-mills in all probability effects molecular changes there also, which have the effect of weakening its strength. The flour dough out of which Scotch bread is made is worked up much more than the dough for English bread. The effect is that Scotch bread is of a whiter colour but of slightly sub-acid flavour. Working up too much almost any sort of dough, or straining too often any metal, has an effect in some direction or another.

Some authorities take the view that the rubber is just a gum and that the working in the mills has no more effect on its constitution than stirring a gum-pot would have on the gum. This, however, is wrong. It is one thing to stir the gum in a pot slowly by hand and quite another to churn it rapidly with machinery. When the latex is coagulated it may not have ceased to be a gum, but it is a manufactured gum with altered ingredients incorporated in it and changed properties. The conditions are therefore entirely altered.

FIG. 56.—A Battery of Mills—Direct Drive (Bridge & Co.).

Throughout this chapter illustrations of various standard types of washing-mills by leading firms of engineers are interspersed. All these firms make excellent machinery. All have their machines working on various plantations, and it is rare to hear of any expressions of dissatisfaction. For this reason no special make is singled out for higher commendation than what is equally bestowed on the others.

The type of mill most popular in Ceylon is, curiously enough, not that which specially commends itself to up-to-date planters elsewhere. Ceylon planters go in for belt-driven mills, while in the Federated Malay States, the Straits Settlements and in Sumatra the mills are driven by machine-cut gearing and friction-clutch direct from the main-line shafting at the back of the mills. This shafting is usually run at a speed of 75 to 100 revolutions per minute. The Ceylon style does not appear so suitable. The use of belts always means a loss of power generally estimated at from 10 to 15 per cent. Now, if a planter has an engine of, say, 50 horse-power, and is losing from 5 to 7½ horse-power every working day, it is easy to estimate the annual loss involved. By the other method of drive the loss of power is minimized. The risk of accidents to coolies and others attending the mills is also lessened.

Planters should always specify the back-driven type of mills, as in these the drive is kept clear of much of the dirt and water showered down on centre-driven mills.

There is a tendency to increase the diameters of the rollers on mills. Formerly 9″ × 18″ was the standard in the Federated Malay States, but recently orders have been received by engineers for mills with rollers 14″ × 24″ in diameter. Such large mills indubitably take more power to drive them, but they do more work and the rollers last much longer—no small advantage.

The water used for purposes of washing and manufacturing rubber should be pure, otherwise first-grade rubber cannot be turned out. Many managers seem very indifferent about this matter, and are content to use well or river water without any attempt to purify it. Wet sheets of rubber should never be carried out into the sunlight from the factory to the drying-house. A properly-covered-in, not merely roofed, passage should always be erected. If the drying-room is situated above the factory, of course this instruction is not necessary.

CHAPTER XXV

DRYING RUBBER

AFTER the sheets of rubber come from the washing-mills many planters hang up the day's output at one end of the factory in order that superfluous water may drip off during the night before the rubber is sent to the drying-house. In one factory there is a sloping platform behind the mills covered with zinc, on which the sheets of wet rubber are laid down so that the water may, to a considerable extent, run off before the sheets are dispatched to the drying-shed.

Drying-houses should be so constructed as to ensure a good circulation of air. There should be numerous openings all round the sides on a level with the floor, other openings all round the eaves, and several large ventilating openings with cowls on the roof. Warm, stagnant air without circulation will not dry rubber properly. A cement floor is essential. If wooden flooring is used, or the drying-house is built without any floor, dampness will always be drawn up from the soil and the rubber sheets will be covered with mould spots.

Several estates construct their own drying-houses, purchasing, locally, cement, expanded metal for the openings, galvanized-iron sheeting for the roofing, and obtaining from their own jungle-reserves the hard-wood timbers required for the framework. A drying-house 100 feet long by 30 feet wide, put together in this way, costs about £800 in the Federated Malay States. Where this is not convenient local engineering firms are always willing to tender for the supply and erection of such buildings.

Herewith are given details of two such buildings, the first one being supplied and erected in the Federated Malay States and the second one in Sumatra.

Steel building for drying-house, 60 feet long by 40 feet wide, 10 feet high at eaves, 3-in. rolled-steel stanchions at 15-feet centres, 40-feet-span steel trusses supporting steel angle-purlines and corrugated-iron roof. Sides of building of corrugated iron fixed to steel angle-stringers. One foot of 3-in. mesh expanded metal to be fitted all round the building. The stanchions to be bolted down to concrete foundations and the floor to be of 3-in. concrete rendered with the best Portland cement and sloping to concrete drains all round the building. Seven windows to be supplied, 5 feet by 3 feet, with wooden frames and shutters. One doorway with iron-framed door

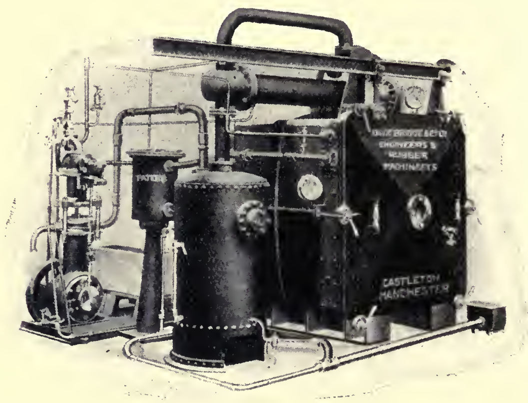

FIG. 57.—Bridge's Vacuum Drier.

covered with corrugated iron. Total cost erected on site, £375.

Drying-house erected in Sumatra. The building to be of steel, 90 feet long by 40 feet wide and 25 feet high. The roof to be of No. 24 corrugated iron. Three floors, the first to be of concrete. An iron stair to be supplied to the first floor and a wooden stair to the second floor. Twelve windows. Cost erected on site, £530.

Most planters now specify for a wooden roof under the corrugated iron roof, as otherwise the building is apt to get too hot for comfort.

The latest suggestion is to build drying-sheds without any walls at all, that is to say, with only expanded metal sides. In

Fig. 58.—View of a Rubber Drying-shed.

wet weather matting or shutters on the sides would certainly be required to protect the sheets of rubber from the driving rain.

The time taken to dry rubber is often a consideration, and in damp weather the delays are often considerable. Hence many planters are now installing drying-machines. The sheets of rubber are laid on trays, and hot air, at a temperature of

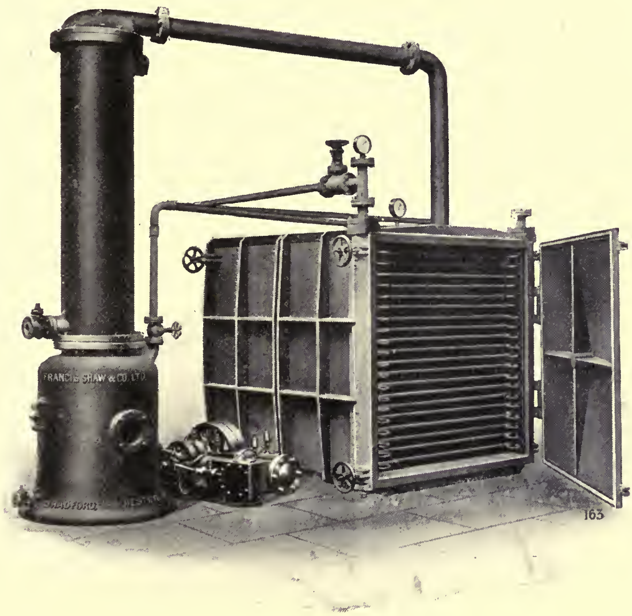

FIG. 59.—Shaw's Vacuum Drier.

90° to 110° Fahrenheit, is generated by a furnace outside and blown through the chambers containing the rubber. By such means the thin sheets of crêpe-rubber can be perfectly dried in from three to four hours' time. A rapid output of rubber is ensured and there is no risk of mouldy spots appearing.

It is, of course, essential that careful watch should always be kept that the rubber in the chambers does not get overheated or it will be damaged, if not altogether spoiled. Some managers object to the use of these hot-air driers, as they consider that they can always dry their rubber in their drying-sheds and turn out a better quality of rubber. Others take quite an opposite view. In any case hot-air drying-chambers are a very great convenience and enable rubber to be turned out with very considerable dispatch.

As the demand is now large, most of the large firms who cater for the rubber-growing industry make such driers. The driers are now made to use oil-fuel when desired. This is a great benefit to many estates where other fuel is scarce and expensive. Oil can be readily purchased at moderate cost in all Eastern lands where rubber is grown. At the same time it ought to be stated that oil-fuel driers are very much more expensive to operate than those which use timber or coal. Four gallons of oil-fuel per hour for a drier makes quite a serious addition to expenses. Improvement in construction is called for and should not be unattainable.

A drier to deal with 150,000 lbs. of rubber per annum costs about £250, to which have to be added the costs of erection, say £30.

Vacuum driers are in use on some very well-known large estates, turning out a high quality of rubber. The principal objection to their use is that they almost inevitably demand the attention and constant presence of competent, trained engineers to operate them. On small estates this is not convenient. Two types of these driers are illustrated here.

CHAPTER XXVI

SMOKING RUBBER

IN the Amazon district in Brazil, where the bulk of the world's supplies of "wild" rubber have come from for about eighty years, the method of curing the rubber is simple. The pails of rubber latex are brought in to a hut or roofed shelter for smoking. A fire is made up with bark, nuts and wood, so as to give off a dense and astringent smoke. When this is ready the natives dip a paddle or pole with a flat blade at the end into the pail with the latex and pass it over the smoky fire. In a few seconds a dried film of rubber is formed on the paddle. This operation of dipping and smoking is repeated till quite a huge ball of rubber, composed of countless layers of rubber films, is formed on the paddle. When the ball is too large for convenient handling the paddle is suspended over crossed sticks to relieve the workers of the weight of the heavy ball, and the latex is then slowly poured on in a thin stream on the revolving paddle till no more latex is available or the ball is too large for convenient handling.

The object of this smoking is to thoroughly cure the rubber, as the latex contains many proteins which would otherwise set up an active fermentation and become putrescent before the rubber reached the warehouses. In the crêpe-rubber manufactured on plantations nowadays these proteins are, in most cases, well washed out in the washing-mills, and thus smoking is not strictly necessary in the case of crêpe-rubber. Of course, a second effect of the smoke is to coagulate the rubber.

When trees first came into bearing on Eastern plantations the latex was allowed to dry on the trees. The scraps and strips of rubber were then collected, rolled up anyhow in a ball or lump and sent to market. This was found to be clumsy and inconvenient, as the rubber was full of dirt and particles of bark.

When coagulation with acetic and other acids was first employed the latex was poured into numerous small, shallow pans, the coagulated rubber floating upon the tops of these pans in the form of what was called a biscuit, about 9 inches in diameter and ¼ of an inch in thickness.

It was soon found, however, when large numbers of trees came into bearing, that the number of small pans which would be required was simply enormous. Large coagulating vessels and machinery were introduced, and this had the effect of permitting large quantities of rubber to be expeditiously treated. Attention then became directed to working-up the crêpe so as to obtain the clearest golden colour possible.

Smoked rubber, however, has always had its advocates, both among estate managers and manufacturers. Although the same fine colour cannot be secured when rubber is smoked, colour is far from being everything, and indeed there is no doubt but that far too much importance is generally attached to it, putting into the second place far more important qualities.

The endeavour to free rubber from as much as possible of resin and protein matters, so that it may keep better, is doubtless founded on a mistaken idea, namely, that the purer the rubber the better the quality. This, it seems to me, is an entire error. Synthetic chemists acknowledge that the great fault and misfortune of the substances which they produce is that they are too pure. The presence of minute quantities of what are regarded as extraneous substances in, for example, natural indigo as opposed to synthetic imitations, secures for it a triumphant superiority in quality. If synthetic rubber is ever in the future put on the market in quantity, I venture to prophesy it will be found to be markedly inferior in quality for the simple reason—over-purity. So with rubber; what should be aimed at is early and complete antiseptic treatment of the latex to prevent the action of bacteria setting up fermentations which weaken the nerve of the rubber, and, if allowed to proceed too long without effective check, produce "tackiness." Thorough smoking of entire latex-rubber produces a better rubber than is procurable by washing and tearing and tearing and washing the rubber in the mills till much of the protein matter is removed and the risks of fermentation thereby lessened.

With regard to methods of rubber manufacture we shall doubtless see many changes in the near future. Rubber in the form of crêpe—although clean and dry and generally of fine colour—has many disadvantages, and is not likely to be the permanent form in which plantation rubber will come to the market. While it may suit manufacturers of rubber solutions, and be perhaps freer from moisture than any other form of rubber, it is expensive to manufacture and is not so strong and does not store well. Rubber solutions are, after all, a very small portion of the requirements of the rubber industry. There has been in the past too much emphasis laid on colour by Mincing Lane buyers and too little on strength and keeping qualities. Time will change all this, and time will change this soon. Already some of the very largest manufacturers of rubber goods make no secret of their personal preference for smoked rubber. They state that they find crêpe-rubber requires to be very carefully stored, kept at certain temperatures and away from sunlight, and this entails expense. Even when all such precautions are taken it does not always keep well.

On the other hand, they state that well-smoked rubber can be stored almost anyhow and improves by keeping. Stocks can therefore easily be laid in and kept any length of time till required for manufacture. These views, representing as they do views of large consumers, demand serious and careful consideration.

The demand which has set in for smoked sheet with a well-defined diamond pattern is due to the fact that this style of sheet is less likely to become mouldy when packed, and generally arrives in a good condition. When the sheets are smooth, little air gets in between them when packed in chests, whereas the diamond pattern, when deep, sharp and well defined, permits of a circulation of air and the sheets are less ready to adhere to each other. The sheets are, therefore, less readily affected by damp during the voyage.

For this style of rubber sheets it is best, after roughly forming the sheets on the macerator or crêper—although the use of these mills can be dispensed with—to pass them through a sheeter with smooth rollers once or twice. When the smooth and regular surface has been secured, the sheets should then be passed once only either through a diamond pattern crêper or, preferably, if a well-defined pattern is desired, through a sheeter with diamond pattern rollers, as there is less friction on this mill.

It has become a common practice to have on this last sheeter the name of the estate countersunk on the rollers. Only first-grade sheets are usually passed through these rollers, lower qualities being finished on other mills. This is a course to be commended and one which will doubtless become general.

When passing the sheets through the sheeter for the last time, the water running from the pipes overhead should be turned off so that the sheets may be as free as possible from extra moisture before being sent to the drying-house or smoking shed.

A point to be borne in mind is that when smoked sheet is turned out instead of pale crêpe, a very much larger proportion of the sheets can be marketed as first quality. On many estates the colour and the purity of the water varies very much at different seasons of the year. From this and other causes there is always a large proportion of the crêpe-rubber more or less discoloured, and this fetches a lower price than the first quality. In the case of smoked sheet such slight discolourings are not observable. This fact itself, apart altogether from the extra penny per pound smoked sheet commands over pale crêpe, would justify preference being given to the manufacture of smoked sheet.

Smoke-dried sheets vary a good deal in quality. The degree of heating is very difficult to regulate and this may be one of the reasons. Another may be the variety of the fuel and density of the smoke employed. Nevertheless it is generally found that, apart from colour, so far as the main tests of quality are concerned, viz., resiliency, resistance to stretching and recovery, smoked rubber, if tested, will obtain a markedly higher percentage of points than ordinary crêpe.

A wooden house is found to be best for smoking purposes. Houses made of galvanized iron or having stone walls do not suit so well, as the surfaces become covered with deposits of pitch, while, when the building is of timber, the timber, although it turns black, seems to absorb the tar out of the smoke. These wooden houses have attap ceilings, and the small crevices in the timber walls and the ceiling supply just the amount of ventilation which is requisite. It is only when the coolies have to go into the smoking-houses that it is necessary to open some of the shutters to give them air to breathe. The number of fires necessary to produce an adequate amount of smoke and the best fuel to employ are soon ascertained from experience. This should not be left to coolies to decide upon, but should be the subject of careful experiment and investigation by the manager himself, who should then lay down a rule to be followed. In many smoking-houses the smoke is produced from small fires of wood and bark, burning in various spots on the earth. In other cases the fires are contained in buckets, but these soon get burned out and something better is required. By neither of these methods is the smoke in any way purified. If some means could be devised whereby the smoke could be purified of soot without—and this is essential—losing its astringent, antiseptic qualities, great benefits would accrue. This is a matter which is occupying the attention of engineers. Various machines are being experimented with, which blow into the smoking-sheds fumes generated from creosote allowed to fall drop after drop on to a hot plate.

Smoking-houses should be kept quite apart from factories, and in no case should a section of a factory be divided off and used for the purpose of smoking rubber. There is always the danger of fire to consider, a danger much minimized when the smoking-house is kept apart. Cases of fire in smoking-houses are comparatively common, and no precaution should be neglected.

Another point to consider is: What is, or will be, the cheapest method of manufacture? Rubber may not always maintain nearly such high prices as are at present being received for it. A period of low prices for rubber, if at all prolonged, will cause many heart-searchings. In such circumstances desperate efforts would undoubtedly be made to reduce costs of the up-keep of estates and of the production and manufacture of rubber. In other portions of this book ways and means have been indicated by which greater efficiency can be attained in the better conduct of estates, in improving their condition, and by means of better methods of tapping of reducing the costs of obtaining the latex.

The question next arises: Can the rubber be more cheaply manufactured in the factory? It is possible that this may be the case. The method and the machinery may not yet be in existence, but there are many able men, both in engineering firms at home and on plantations abroad, devoting much time and attention to the subject.

To sum up, it may be said that it is a matter of vital importance to the rubber plantation industry that the product it markets in such large and increasing quantities should be of the very highest possible quality. Is it so at present? Clearly it is not so. How is it that fine hard Para and plantation rubber, as a general rule, sell at the same price per pound despite the fact—known and acknowledged—that the loss of weight when a rubber manufacturer washes plantation rubber before manufacturing it is but 1 per cent. of the total amount, whereas in the case of fine hard Para it reaches quite 15 per cent. and is often more?

There are few manufacturers who more closely and constantly scrutinize all items of expenditure than rubber manufacturers do. Competition is keen and prices are closely cut. A rubber manufacturer buying two hundred tons of rubber during the course of the year, at an average price of 4s. 6d. per pound, expends in all £100,800. If with this money he has bought plantation rubber his monetary loss on re-washing at 1 per cent. would amount to £1008. If, on the other hand, he has bought fine hard Para, his apparent monetary loss would be, at 15 per cent., £15,120, the difference being equal to a year's profit on a business of a fair size.

The question then arises—what is the reason that a manufacturer does not eagerly grasp at this apparent saving? It must be evident that—being no fool—he thinks that it is worth while paying £14,112 more for two hundred tons of fine hard Para than he would have to pay to purchase the same quantity of plantation rubber.

Rubber plantation companies cannot afford to shut their eyes against hard facts like this. The tree tapped is the same in both cases. The latex yielded is—to everyone's belief—of the same consistency and quality in both cases. Clearly whatever fault there is in methods comes later. Is it in coagulation? Possibly to some extent. The less of acetic acid which can be used the better. If its use could be entirely avoided it would be a great gain.

It is, however, from the thorough curing by means of smoking thin films and successive layers of the fine hard Para at a time that it derives the special qualities which rubber manufacturers prize so highly and pay so dearly for. If plantation rubber is to compete on equal terms with fine hard Para it would appear that it must be in some form of smoked rubber prepared in a thorough and efficient manner.

To illustrate how vitally important this matter is, let us consider this matter from another point of view. We have spoken of the manufacturer's loss—what of the loss to plantation companies? In the near future some 50,000 tons of rubber will reach the market from plantations in the East. If fine hard Para is then selling at 4s. 6d., and plantation rubber was then thought to be of equal quality and paid for at the rate of 4s. 6d. per pound also, but plus the actual difference in weight after washing, then each pound of plantation rubber would sell at nearly 5s. per pound, and plantation companies would receive, approximately, £2,800,000 more money for the 50,000 tons than would be paid on the present footing. This money seems worth looking after.

A further important point which should not be lost sight of is that if supply should at any time overtake demand, the salvation, if not of the rubber plantation industry, or at least of some of the weaker companies engaged in it, may have to be found in the fact—if fact it then is—that plantation rubber is fully equal in quality to fine hard Para. If it is, it will be purchased in preference and command a sufficiently higher price to yield a fair profit to plantation companies. In that case the Brazilian exporters will have to face a sore struggle for existence, while supplies of plantation rubber, however large, will, for many a long year, meet with a ready demand at sufficiently remunerative rates.

CHAPTER XXVII

PACKING AND PACKING-CASES

ON several estates the wooden cases for packing the rubber are made from their own timber and by their own native carpenters. The cases are, in such instances, usually turned out a good deal under the cost at which they could be purchased from local agencies. There are, however, not so very many estates doing this as formerly. Timber is not so plentiful as it was at one time, and the demand is for a better-finished case than planters at one time were contented with.

Venesta, Acme, Cochin and Momi cases are in general use and are supplied at reasonable prices. It is important that cases, besides being as light as possible, consistent with sufficient strength to stand rough usage during transport, should be smooth inside, free from all small splinters of wood and from dust, and of regular weight. It is an important thing that where freights and port dues are high the lightest case consistent with strength should always receive the preference. If one figures out these costs and weighs one case against another it will frequently, if not generally, be found that the rough, cheap, heavier case is much the dearer in the end and gives less satisfaction.

Mr J. Ryan, who is well known outside Ceylon, where he has long resided, in a letter to the *Times of Ceylon*, points out that the cheapest case is not necessarily the best to purchase. He says: " Where, as in an account sale before me as I write, freight from Port Swettenham amounts to 75s. per ton and the port rates to 37s. 6d., a saving of 10 per cent. on 112s. 6d. per shipping ton is a factor not to be neglected."

Sheets or other forms of rubber should never be packed in cases till these have been first well dusted out. Three bands of hoop-iron round a case are not too many to bind it together after it has been filled with rubber. When only two are used the cases are sometimes burst open, and complaints on this score, especially from America, where railroad handling is rough, have been reaching us. It is a great advantage when cases are of a regular fixed weight which can be depended upon. The cases should always be filled quite full up. Rubber sheets vary so much in thickness that it is useless trying to arrive at even weights to fill the case.

During the voyage home there is always some loss of weight in the rubber. This may vary from 1 per cent. to 2 per cent., or even more on occasion, according to the original freedom from moisture of the rubber when packed, and sometimes according to what position in the hold of the ship the rubber happened to be placed in.

So far as is possible only one grade of rubber should be packed in each case. If a case cannot be filled up with one grade it is better to keep the lot over till the next shipment. Small lots are at no time in favour with brokers or purchasers.

All spotted or tacky rubber should be kept apart and never put into a case with good-quality rubber or it will bring down the price of the whole lot. This rule should be always strictly insisted upon. It should always be the aim of every estate manager to get top prices for his first-grade rubber and never to be content till he get these. To establish a good reputation for an estate mark is a great achievement, and few things will do more to hinder this than putting in a few indifferent sheets in a consignment of first-grade.

The estate mark, the weight of the case and the weight of the rubber enclosed, as well as the quality, ought to be stencilled on the lid of the case in large, plain letters and figures. A floating policy of insurance should be taken out, which would cover all shipments as they go forward. This is usually attended to by boards at home, but there are still some few private owners remaining, and these must necessarily attend to this matter themselves.

CHAPTER XXVIII

COST OF PRODUCING RUBBER

THIS is a matter which calls for the continual careful consideration of all concerned with the rubber-planting industry. The returns given by various large companies, which are now producing on a considerable scale, vary very much. Some few companies, which have a fair area in bearing, charge the cost of the upkeep of all immature rubber against revenue, which is all right and wise enough when the finances of the company permit of such a course. It is not, however, correct to charge it locally to the cost of rubber production, and it should be left to the boards at home to make such apportionment as they may consider wise.

There ought to be a standard way of arriving at the cost of rubber f.o.b. If out of 1000 acres 500 are in bearing, exactly half of all local charges for rent, salaries and allowances, wages, recruiting, hospitals, visiting agents, local agents, depreciation, machinery, tools and utensils, manufacturing, packing, transport, insurances and assessments—if any—should be counted in against the cost per lb. of the rubber f.o.b. It is the nett cost f.o.b. that concerns one. London charges do not vary much, and there are very few industries where the London charges are so extremely moderate as in the case of rubber.

When any estate is producing 100,000 lbs. of dry rubber per annum the costs should certainly not exceed one shilling and sixpence per lb. f.o.b. at most, and such a figure ought to be looked upon as one which has to be reduced each successive year till it is well under one shilling per lb.

There is no country in the East where rubber is produced at so low a cost as in Ceylon, where the cost of rubber f.o.b. is $33\frac{1}{3}$ per cent. lower than in the Federated Malay States, and leading visiting agents speak with confidence of bringing the f.o.b. cost down to sixpence per lb. The higher costs of rubber in the

Federated Malay States and Straits Settlements are largely accounted for by the much higher salaries paid to visiting agents, managers and assistants there, and the higher rates of wages paid to the coolies. In addition there is the $2\frac{1}{2}$ per cent. *ad valorem* duty on rubber to be taken into account. Under such circumstances it will be easily seen that the rubber-grower in Ceylon occupies a very favourable position. Should rubber in future years fall very considerably in price the Ceylon planter would have much less cause for anxiety than his brothers in the Federated Malay States and Straits Settlements, for a price barely remunerative to them would still be highly remunerative in his case.

Sumatra and Java occupy a middle position in the matter of costs between Ceylon and the Federated Malay States and Straits Settlements. Rubber, if not produced so cheaply as in Ceylon, is certainly put on board ship at a much lower figure than the Federated Malay States or Straits Settlements have succeeded in managing. Salaries and wages are not quite so low as in Ceylon, but are considerably under those paid in the Federated Malay States or Straits Settlements, and there is no *ad valorem* duty.

In course of time salaries and wages will no doubt fall in the Federated Malay States and Straits Settlements to the level of those paid elsewhere, or those paid elsewhere rise to the level of those paid in the Federated Malay States. The latter event is, perhaps, the more to be desired, as a good man is entitled to good payment for his services in a tropical climate, especially when the fact is taken into consideration that the period of active service must infallibly be shorter than would be the case in more temperate regions. If the salaries paid are not sufficient to enable a manager to amass a competency for his old age, the class of men engaged in the industry will assuredly be lowered, the services rendered less efficient, and in turn the industry will suffer.

CHAPTER XXIX

WATER SUPPLY

ON all Eastern estates the supply of pure water is essential to the health of the staff and labour force. Much sickness would be saved and general mortality greatly reduced if a supply of good water was more general. In manufacturing operations it is exceedingly difficult to produce a high quality of first-grade rubber if unpurified well or river water is used in the processes of washing and manufacture. Filter-beds, such as are used largely in Java and Sumatra, do not give very satisfactory results, as the water is always discoloured and never free from animal and vegetable life.

What is known as the "Jewell Gravity and Pressure Filter" has been erected on many estates and has given great satisfaction. It is simple in construction, inexpensive, and easily kept in order. It is supplied in various sizes, to pass from 2400 to 250,000 gallons of pure water per day.

The installation is comparatively simple and may be explained as follows:—Whether the water supply is drawn from a well or from a river, a pump which can be worked by the factory engines is required. By means of this pump the water is elevated to a tank usually standing about 20 feet in height from the surface of the ground. The size of this tank, of course, varies according to the water supply desired. Attached to this tank is the "Jewell" filter, the main features of which are an iron box containing alum, through which the turbid water first passes. By means of gravity the water next passes through a sand bed, contained in an iron cylindrical filter, and emerges clear from a pipe at the foot. A guarantee is given with the filter that it will always supply the stated amount of pure water that will pass the analytical tests of local Government medical authorities. The cost of this system of filtering is extremely moderate.

The filter is easily kept in good working order. There is a handle at the side by means of which the sand can be thoroughly well stirred up to prevent a scum accumulating on the surface and impeding the free passage of water. The manager should see that this is well turned round at the end of each week. Once in six months the sand should be changed, the old sand being emptied out and fresh, well-washed sand put into the cylinder. This is a very simple task and easily executed. These filters give great satisfaction on many rubber plantations.

When well water is used for drinking or cooking purposes every possible precaution should be taken to ensure and preserve the purity of supplies. No well should be excavated within less than 100 to 120 feet of coolie lines or latrines. It is better to erect pumps to pump up fresh supplies than to allow coolies to let down buckets and draw water for themselves. If this is not done, it is hard to keep impurities from entering the wells. The deeper the wells are dug the less likely are the supplies to be contaminated with surface waters from drains.

CHAPTER XXX

WEEDING AND CULTIVATION

THERE is no doubt that to clean-weed an estate and to keep it clean is the most economical way of working. No one will question the necessity of getting rid of lalang at all costs. The long, stringy roots of this most troublesome weed, with their sharp points, penetrate the soil in all directions about 6 to 12 inches below the surface and strangle all other vegetation. Lalang has a wonderful vitality, and it is due to this fact that it is so difficult to thoroughly eradicate it. The smallest portion of a root left in the soil when weeding starts a fresh and vigorous growth. "One year's seeding, five years' weeding," is a saying which expresses the facts of the case. It is only by determined and persistent effort, week after week, month after month, and frequently—when measures are not taken to thoroughly eradicate it before planting is started, or neglect has let it once more establish itself—year after year, that it can be extirpated.

Surface scrapings and light forkings are of no use. Deep forking or chankolling is the only way to get at the roots and to get them out. System and persistent effort are essential. When an estate has lalang it should be divided into blocks of say 50 acres each, and a three-weekly system of weeding started. No more land should be taken in hand at the commencement of the weeding campaign than can be thoroughly well worked over during the period of three weeks. Suppose that three blocks of 50 acres each have been thoroughly well chankolled over during the first three weeks, then, when the second three-weekly period arrives, the same three blocks of 50 acres each have again to be thoroughly worked over. The work the second time will not be quite so heavy, and the estate manager should be able to take in an additional block of 50 acres within the three-weekly period. This additional block having been well chankolled for the first time, the second period of three weeks has closed. The manager then enters on the third period of three-weekly weeding. The first area of 150 acres is a little less difficult to clean up than on the two previous occasions, and the additional block is easier than with the first weeding. With a few additions to the labour force perhaps he may now be able to start work for the first time on a fifth block of 50 acres. Unless, however, he sees his way clear to tackle this block without imperilling the regular three-weekly weeding of the previous blocks, he should on no account be induced to extend the area.

It is marvellous how, after a shower of rain, ground which had been thoroughly well weeded for many three-weekly periods becomes as green as a park. Should a manager have been rash enough to take too large an area in hand, he is apt to be driven to despair at such times. For years the ground seems to be full of seed ready to spring up into fresh vegetation after every shower of rain. It is only by persistently wearing the lalang down on moderate areas and adding small acreages to the weeding round when work is well in hand that lalang can be got under.

Five to six pounds sterling per acre is no uncommon expenditure before the lalang is sufficiently under control to reduce weeding to the ordinary monthly round.

Once lalang has been got under control the following is a fair average of how ordinary weeding-costs should work out each successive year. It is to be borne in mind that weeding is being spoken of, not cultivation, two very different things. The cost of deep forkings and chankollings are not included in the figures first given.

Costs of Weeding, per Month, per Acre

	Ceylon	Sumatra	F.M.S.
1st year	R.2.50	G.2.50	$2.50
2nd ,, ...	1.50	1.50	1.50
3rd ,, ...	.60	.60	.60
4th ,, ...	·35	·35	·35
Light forking or chankolling, per acre, each time . .	1.50	1.50	1.50
Heavy ,, ,, ,,	3	3	3

Where the lay of the land is flat, disc-ploughs or cultivators are employed on several estates. These, as ordinarily employed, are of no use for getting rid of lalang, but once lalang has been extirpated they are useful in keeping down light weeds, if it is desired to do so, at a cost of about fifty dollar cents per acre. Furthermore, as explained elsewhere in this book, the advantage of having the surface of the soil broken up is very great, as it prevents an immense loss of moisture which would otherwise evaporate, and it has thus—for all practical purposes—the effect of materially conserving the rainfall and so assisting the more rapid growth of the trees and adding to their power of resistance to droughts. Such methods, however, are but a poor substitute for chankolling. The ploughs usually employed only turn over 2 or 3 inches of surface soil, and going over the soil with them is not cultivation. A well-known planter who had been trying such ploughs at the request of his board, was asked by another planter who was on a visit to the estate what he thought of them. " See here," said the planter, pushing his walking-stick into the ground the ploughs had just been over, " the top 3 inches of soil are loose, but the ground is caked hard below and my walking-stick won't go down." The object-lesson was better than words. Still, such ploughs at least break up the surface of the soil, and that is better than nothing, as the rainfall then penetrates the soil and does not for the greater part promptly run off into the drains. Of course, ploughs can only be used on level ground free from stumps or rocks.

In actual practice the costs of weeding by means of cultivators work out as follows:—

Wages: Two men, with four bullocks at 40 cents per coolie per day, cultivate five acres daily .	$0.16	per acre
Food for four bullocks at $10 per month, each bullock working, say, twenty-five days per month .	0.32	,
Depreciation on bullocks and cultivators . .	0.10	,,
	$0.58	,,

On some estates where the benefit of cultivation was recognized, but inadequate financial resources exercised a restraining influence, a compromise was resorted to. Circles round the young trees were well dug over with marked improvement in the appearance and the growth of the trees. Where the trees were very young they were dug round within a radius of 4 feet. This cost $1.20 per acre. Older trees were dug around within a radius of 8 to 10 feet at a cost, in this case, of $3 to $4 per acre, the wider circle involving, of course, very much more digging. The cost, however, seems very high for the work.

While agreeing that clean-weeding—from a strictly monetary point of view—is generally the most economical and the best method of working, and that lalang must be got rid of whatever

FIG. 60.—Cultivation by means of Bullock-ploughs.

the expense may be, I am persuaded that clean-weeding is sometimes rashness.

On estates which are very hilly, and have very steep slopes subject to severe wash of soil, clean-weeding is generally most unwise. The surface-soil is the rich soil—rich in vegetable humus. It is full of bacterial life. If washed away it cannot be replaced. The best way to retain this surface-soil in such cases is to encourage the growth of light and harmless grasses and weeds. The roots of these do not penetrate into the soil more than from 2 to 3 inches, and do not interfere much with the tender surface roots of the young Heveas, which are from 4 to 5 inches below the surface of the soil. Their presence does not greatly retard the growth of the trees, although it certainly does retard them.

Of course, some qualification of the foregoing should be made. Where companies can face the expense of terracing, contour-drains, water-pits and other means of preventing wash of soil, and the outlays for their annual upkeep, then, except in the case of very steep slopes with loose, friable soil, such methods may be, and often are, adopted instead of encouraging the growth of grasses or light weeds. The weeds certainly hold the soil best and the cost is also much less, hence the practice of employing them for this purpose is spreading greatly in the Federated Malay States and in Sumatra during recent years.

Clean-weeding under all possible circumstances used to be an obsession with many leading planters, so much so that they would hardly discuss the subject, and looked upon anyone who ventured to dispute their verdict as a pariah, or at least a person void of common sense. Matters are changing in this respect, and in Sumatra, at least, many of the best managers are encouraging the growth of light weeds, even on flat land, a course which cannot be approved of.

Weed coverings on flat land are thought by some to be advantageous from the point of view that they keep the surface of the soil moist. This is just exactly the principal reason why they are objectionable. When the surface of the soil is moist it means that heavy evaporation is going on and that the valuable moisture from the rainfall which should be stored up in the sub-soil is being wasted. The reasons for this are discussed at length in the chapter on The Soil and on the next page. It is because weeds drain away from the trees their stores of moisture necessary for good growth that trees in weedy plantations are so very backward in growth. Where it is possible, by means of contour-drains or water-pits, to do without coverings of grass or weeds on slopes which are not too steep, it is best to do so. If a company can afford the considerable costs involved in a very thorough system of contour-drains or water-pits, and the labour and the outlays involved in frequently clearing them after rains, then this course is the best to follow. Where, however, the soil is very loose and the slopes very steep, then the danger of losing the surface-soil by wash, or the bodily sliding away of large masses of the soil on the slopes, is so very great and the consequences so serious that it is distinctly preferable to encourage some sort of light weeds as a protective covering. It is when the ground is first cleared that the most mischief is done. At such times, when the former growths of weeds which bound the soil together are dug out, a shower of rain involves an immediate landslide. There is no time, even if it were possible, to make drains or water-pits before the surface slides away. Indeed, in such circumstances, drains and water-pits are an additional provocation to huge slides of land. It is best, therefore, not to clear too much of a steep hillside at once without doing some immediate work to protect the soil. If trees have been felled the logs should be laid lengthways along the hillsides and belts of grass or hedges at once installed.

In Ceylon, where the soil is so often very rocky, terracing can generally, although not always, be done. Very serious damage has been done to native rice-fields in some instances by heavy washing-down of surface soil from cleared areas, and compensation has had to be paid. Belts of grass and other means had to be established to aid the contour-drains in retaining the surface-soil.

Once lalang has been eradicated no good manager should have difficulty in keeping light weeds on steep hillsides in order. From time to time they should be scythed down and dug in when the soil is being chankolled over. In this way they act as an excellent mulch to the soil and greatly add to its fertility.

Great advances have been recently made in what is called "dry-farming" in various parts of the world by means of which large tracts of arid or semi-arid regions have been brought into successful cultivation. The success of this dry-farming mainly depends upon the application in practice of two simple propositions, the bearing of which on rubber cultivation as well as dry-farming should be obvious.

The first proposition is based on the well-known fact—elsewhere insisted on in this book—that a cultivated soil absorbs more water than an uncultivated and, therefore, more impervious soil.

The second principle, also discussed at length elsewhere, is founded on the fact that a loose layer on the surface of the soil greatly assists in preventing evaporation of the water stored up in the sub-soil. These facts have their bearing on the successful cultivation of rubber also, and although ignored by most rubber-growers, can scarcely be too much or too often emphasized.

As pointed out elsewhere, chemical analyses may show that all the necessary chemical ingredients for fertility are present in the soil; but if they are in a locked-up, insoluble form they do not lend their assistance to the growth of plants. "Availability" is the crux of the matter.

Cultivation has the greatest possible influence in rendering "available" the useful constituents of the soil. This is not only because forking, chankolling or ploughing turns up fresh mineral food from the sub-soil and the roots get hold of it. It is also because the aeration of the soil revivifies and stimulates the activities of bacterial life. Were the bacteria all to die out of the soil no amount of expensive fertilizers would be able to keep vegetation long alive. Every chemical ingredient might be present in ideal quantities in the soil, and yet plants and trees would speedily starve to death.

Mr Alma Baker, in the *India-rubber Journal*, 5th September, 1910, strongly advocated chankolling everything once every three months from the time of planting. "The system has," Mr Baker states, "the following advantages:—

"1. It prevents all surface wash from the beginning.

"2. It enables the land to retain more moisture.

"3. The land does not only retain all the plant food it originally had, but has in addition the humus derived from the vegetable matter turned in four times a year. Also, the turning up of the under-soil renders readily available, through exposure to the atmosphere, a portion of the otherwise unavailable salts.

"4. It forces the tree, by cutting the small surface laterals, to root firmer and lower and to take its nourishment from cooler, damper and richer soil.

"5. It greatly helps in the eradication of Fomes and white ants, as it clears the land of all small pieces of timber, at the same time opening up the soil for the air and sunlight to penetrate."

Mathieu also suggested that systematic root-pruning by means of chankolling would give great benefit to rubber trees. He says: " When the roots have reached the limit of their feeding-ground they cease to spread. They then coil up and form tangled masses through every inch of the ground, till, space lacking, they cease to throw up new feeders." He is of opinion that a partial and light cutting of the roots at the extremity of their feeding-ground revives them to a very great extent. The opening of the ground, he says, causes moisture to penetrate farther, and the roots strike down at once into new layers of soil. Thousands of new rootlets are thus formed. To carry it out he advises the making of a trench 1 foot deep between the rows of trees, and, say, 10 feet distant from the trunks. Then two parallel trenches should be dug 1 foot on either side of the first one, but only 4 inches deep, so as not to injure the main roots.

There can be little doubt but that in the main feature of their contention, namely, the necessity for regular and thorough cultivation, Messrs Baker and Mathieu are clearly in the right. While admitting, however, that root-pruning, once in a while, is attended with great advantage, the constant pruning of the roots every three months advocated seems a very questionable policy. It is more than doubtful if the trees would not suffer. It would appear to be better to prune the smaller roots by chankolling not oftener than once every two or three years, and at other times to fork over the soil round the roots. No doubt occasional pruning of the roots is a great help in the growth of trees, provided a clean cut is made. It has long been the practice to prune the roots of fruit trees, with very beneficial results to the crops.

On stiff clay soils tillage has a special advantage, not only on account of the loosening of the soil, but from the fact already stated that tillage has the peculiar effect on clay soils of causing the very fine particles to cling together, and thus the soil becomes a little coarser. Moisture is more easily able to penetrate the soil, and in dry seasons the roots of the plants can draw up the moisture from the sub-soil more easily.

The question naturally arises, What cultivation can be done between rows of rubber trees planted at moderately close distances? In such cases it is best first of all to thin out all poor, badly-grown, misshapen trees, and all poor milkers. When these have been felled and removed the roots must be extracted.

After this has been done the soil should be well chankolled over, at a distance of about 8 feet from each of the remaining trees. This chankolling will have the effect of pruning the roots, and will stimulate growth. Nearer the trees, where there are larger roots, the ground should be well stirred up with sharp-pointed sticks, so that it may be thoroughly aerated and the beneficial bacteria stimulated to good works.

On the well-known Pangkattan Estate, Bila, Sumatra, belonging to the Sumatra Para Rubber Company, Limited, the effect of chankolling on the roots of rubber trees was very marked. Some of the old trees rather closely planted were beginning to suffer, and the yields of latex were falling off somewhat. Sixty acres were selected for experiment, and deep chankolling was done about 8 feet from the trunks of the trees. Nearer to the trunks of the trees the ground was well stirred up with sharp-pointed sticks, so as to injure the main roots of the trees as little as possible. The effect of this experiment was very marked. For three months the yields of latex fell off owing to the drastic treatment the trees had undergone by the disturbance of the root system. Thereafter the trees picked up wonderfully. The 60 acres selected for experiment gave an increased return of latex over the figures for the previous year of 250 lbs. per month of first-latex quality (second-latex quality and scrap not included). This was a very marked improvement. To very many planters the message might well be given—Go thou and do likewise!

CHAPTER XXXI

WEED COVERINGS

THERE are a variety of methods employed to keep down the growth of weeds and to reduce weeding expenses. With many rubber companies money is not too plentiful, and there is a constant demand made on the manager to keep down weeding costs by all possible means.

Under such circumstances managers often plant up their fields with coverings of passiflora, kratok, crotalaria, mimosa, indigo or other leguminous plants with the idea of enriching the soil while at the same time keeping down weeding costs.

None of these coverings are free from objection. Passiflora is generally difficult to establish. It grows in patches and leaves considerable areas of the soil without covering. If the object is to keep down weeds it is often a signal failure, although in the case of low-growing weeds, such as the very troublesome teki or kora grass, it has on occasion been a success. I have scarcely ever seen passiflora that was not full of weeds. It frequently helped as a shade and shelter for lalang, which it was incapable of smothering. It also affords a comfortable domicile for rats, snakes and other vermin. Altogether, whether in Ceylon, the Federated Malay States, Java or Sumatra, in every case where I have seen it introduced it has been a failure.

Kratok is another covering employed for the purpose of reducing weeding expenses. It grows much more luxuriantly than passiflora in Java and Sumatra, which are the only countries in which I have seen it employed. The soil is soon covered with a thick mat of vegetation, about 1½ feet in height. Like the covering of passiflora, it is also full of other weeds, and affords an even better shelter for vermin than passiflora does. If one lifts the mat of vegetation the soil will be found wet and dank underneath. On Boekit Maradja Estate, Sumatra, where this covering was tried on a limited area, the young trees looked six months behind those in surrounding areas of exactly the same soil and, otherwise, under exactly the same conditions, proving that the roots of the kratok hindered the expansion of the roots of the young Heveas and, by draining the soil of moisture, hindered growth. In the opinion of the writer this covering, therefore, cannot be regarded as a success, and any very problematical gain obtained from the reduction of weeding expenses is far more than counterbalanced by the retardation of the growth of the trees. Kratok is a most difficult covering to keep within bounds once it has been started. Unless considerable care is exercised, and considerable expense incurred in continually chankolling it back, it will encroach on the clear circle usually preserved round the roots of the young trees.

Crotalaria is another covering very similar to kratok in its growth and conditions, and the same remarks apply word for word. It grows to an even greater height, interferes with the working of the estate, and gives vermin a very complete shelter.

Mimosa is very largely employed in Sumatra as a covering, and with much more success than any of the previously mentioned coverings. It is not the ordinary mimosa seen growing wild along roadsides in Ceylon and Sumatra, but is grown from seed procured from Java. So great has been the demand recently for seed that prices are high and seed costs about G.40 to G.50 per picul. This mimosa branches well, and from a single stem a covering spreads about 7 feet in every direction over the surface of the soil. The roots go down about 6 inches, and one can easily observe on them numbers of nodules, *i.e.*, bacterial gatherings. These nodules have valuable fertilizing properties, and can also be seen on the root systems of dadaps and many other leguminous plants. An illustration of these nodules upon mimosa roots appears on page 22.

It has been estimated that by ploughing in mimosa a very considerable amount of nitrogen, amounting to about 200 lbs. per acre, can be added to the soil. By burning, much of this is lost, but by no means all, as the nodules are on the small roots of which many are left in the soil.

The mimosa should be planted in belts down the centre of the avenues between the rows of trees, and cut back from time to time. Some planters allow the mimosa to overrun the whole field, others try to keep circles clear round the trees. There is no doubt, however, that much the best method is to plant in belts. This allows coolies to walk up and down the rows of trees, which the thorns of the mimosa would otherwise prevent. As the mimosa is apt to grow high if not hindered, it is usually beaten down from time to time by means of flat planks attached to a short pole.

The plants are usually about 6 feet long by 1 foot broad, and the poles to which they are attached are usually about 4 feet long. As the thorns of the mimosa are all there and mean

FIG. 61.—View on Tamiang Estate, North Sumatra, showing Mimosa Covering between Rows of Trees.

business, the coolies have to be provided with shoes, and wrap strips of old garments round their legs to preserve them from being severely scratched as they walk over the mimosa while beating it down. This, of course, is more necessary when the mimosa is allowed to overrun the ground than when it is planted in belts. Some managers have claimed that lalang cannot grow where mimosa is planted, as the mimosa clings with its thorns to everything, overruns and smothers it. The writer was shown lalang to which the mimosa was clinging and bending down; but, while willing to admit that most weeds would be suppressed by the mimosa, the writer would make certain of getting out all lalang before mimosa or anything else was planted as a cover. Certain it is, however, that no vermin harbour in mimosa, and monkeys will not cross over it, so that in these respects it has a distinct advantage over other coverings.

Two objections have been raised to the use of mimosa as a covering. The first is the difficulty of getting rid of it once it has been established. The difficulty does not exist. Mimosa is very easily cut back, and the roots are very easily dug out.

The second objection is the danger to the plantation from fire. This, also, is not serious, unless as the result of ignorance or neglect. If the mimosa is allowed to overrun the fields and is permitted to remain more than from twelve to fifteen months without its being cut down and burned, there certainly would be a danger. If only allowed to remain for the above-mentioned period the mimosa is always fresh and green, but long-established coverings of mimosa would naturally have dry and decayed stems and a litter of leaves which, during a drought, would be inflammable.

To obviate this risk the mimosa covering is cut down every twelve or fifteen months, and the cuttings burned at nights in the centre between the rows of trees. The cuttings only smoulder away, and a careful manager always sees that trustworthy coolies keep a watch in case of accidents, such as strong wind springing up suddenly. It would, of course, be very much better to dig in this valuable green manure than to so wastefully burn it. Digging it in would add materially to the nitrogen contents of the soil. The same remark applies to all other coverings.

Indigo is sometimes planted as a cover and catch-crop combined. It is also a leguminous plant. It is a much larger plant than any of those already mentioned. Its presence does not keep down weeds to any extent worthy of mention. Where it is planted, as on some estates in Sumatra, with the intention of cutting it down and digging it into the soil so as to enrich it, it is not objectionable; but if intended as a catch-crop I should consider it a hindrance to the growth of the young rubber.

In the writer's opinion all the foregoing covers are frequently more or less of a mistake. They are cultivated generally on the assumption that, once lalang has been eradicated, something must be done to keep down weeds and weeding expenses. Where lalang has not been thoroughly got rid of, the before-mentioned coverings can scarcely be relied on to suppress it and are a hindrance to its removal if there.

In the case of Ceylon, owing to the rocky soil, planters seem to have more difficulty in keeping their weeds in check there than anywhere else. In Sumatra, however, no difficulty is experienced by many planters in pursuing a policy of encouraging the growth of light weeds on hilly ground and yet keeping them under sufficient control. The light weeds are from time to time dug into the soil and thus supply a most valuable green manure, which in the case of light soils greatly improves their texture, and in the case of clay soils aerates them and helps towards a freer circulation of both air and water. In this, as in many other matters, no universal law can be laid down.

CHAPTER XXXII

WASH OF SOIL

AS already stated, in cases where land is very steep and hilly, and the soil is loose in texture, clean-weeding is frequently a very serious error. Surface-soil lost is not easily replaced. With the surface-soil swept away, most of the fertility of the soil has gone, and the trees inevitably must have a poor and backward growth. Of this examples are not lacking.

The manager of a very well-known Sumatra estate recently was lamenting the effects of a previous policy of clean-weeding. " On our estate," he said, " we have a large proportion of fairly steep land and the surface-soil is all gone. It has been washed away. You won't find us be such fools again," he added.

Especially is it necessary to protect the soil from surface-wash in the case of young plantings, where the roots are not developed and, therefore, do not bind the soil together. In such cases light weeds are almost indispensable and, indeed, may be said to be altogether indispensable unless some other method of preventing surface-wash is adopted. To prevent this lamentable washing away of surface-soil many means besides encouraging the growth of light weeds are employed. In Java a common method is to grow belts of lamtora or clitoria right across the slopes between each row of trees. These hedges are regularly cut down, so as to keep the hedge within 1 foot, or $1\frac{1}{2}$ feet from the ground. As the hedges grow very close they serve the purpose of intercepting washed-away soil very well, and the cuttings of these leguminous plants provide a very good green manure for the enrichment of the soil. The hedges should never be planted too near the young rubber trees or their roots will interfere with those of the young Heveas. Eight feet from the tree is about the correct distance.

Still another method of intercepting washed soil is by digging

FIG. 62.—View of Sungei Ular Estate, showing Grass growing between Rows of Trees to prevent Soil-wash.

FIG. 63.—Hill Slope with Covering of Ageratum Mexicanum to prevent Soil-wash. Trees Circle-weeded.

long water-pits, which serve the double purpose of retaining washed-away soil and rain, which would otherwise run off in the drains.

These pits are dug along the sloping ground, as illustrated in the sketch given overleaf. They cost G.8 per acre to dig out in Java, but the great drawback is that every heavy shower of rain leaves them filled up with soil and they require continued digging out.

FIG. 64.—View of Roots exposed by Wash of Soil.

I have known them to be filled level six times a year. At each time it costs nearly as much to dig them out as at the time they were first made, and this expense has to be incurred at least from four to six times a year on an average. The total outlay may average about G.20 per acre per annum.

There is also the additional difficulty that on very steep hillsides these water-pits cannot well be dug out at all, or, if dug out, would be almost immediately filled up; and besides this, on steep land these pits are apt to induce the soil to slip away bodily in large masses. Where hillsides are very rocky, as is frequently the case in Ceylon, their construction is almost an impossibility.

In such cases terracing—although the first outlay is expensive—is a much better solution of the difficulty. Where no stones are available, as in Sumatra, belts of guinea-grass are often employed to prevent wash. These cost little—like politeness—and, like it, are worth much. The cost of these

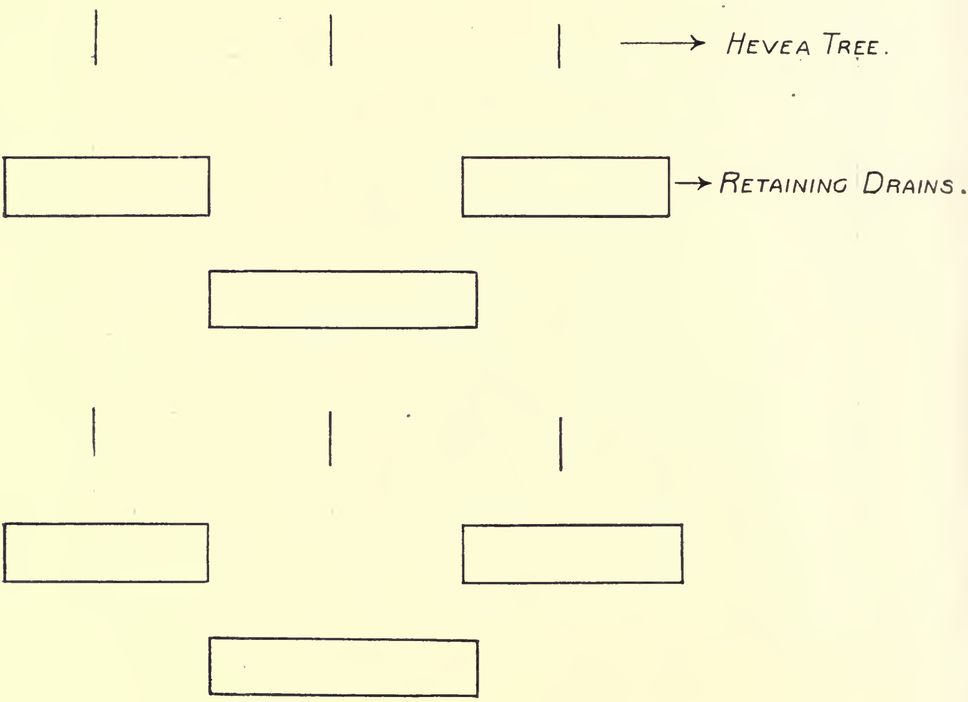

Fig. 65.—Diagram of Water-pits for Retaining Soil-wash.

on a well-known Java estate has been found in practice to be from one shilling and sixpence to two shillings per acre.

When the Heveas have reached a more advanced age their roots, well spread throughout the soil, assist in binding it together, but for some years breakwaters of some kind are indispensable on hilly land.

While methods may have to vary in different countries and under different conditions, it is clear that in all cases effective

FIG. 66.—View of Contour-draining to Prevent Soil-wash.

FIG. 67.—Palisade Protection for Roots that have been Exposed by Wash of Soil.

means must be taken to prevent surface-soil being swept away. Where clean-weeding of steep slopes has been insisted on against the manager's convictions, the writer has seen immense masses of soil slide bodily down the hillsides, taking everything with them. Had belts of grasses or hedges been planted, no doubt this might in some cases have been prevented, but even these are not always sufficient to retain masses of light porous soils on very steep hillsides.

The names of many well-known estates in Ceylon, in the Federated Malay States, in Java and in Sumatra, might be mentioned, if occasion demanded it, where such landslides occurred, sometimes with damage to neighbouring properties. The man on the spot, if capable, ought to be the best judge of what methods will best serve in each particular case that arises. Economy and efficiency ought always to work hand in hand.

CHAPTER XXXIII

MANURING

WHEN it is desired to take samples of soil and have them tested by a chemist, care should be taken to ensure that the samples are really representative of the soil as a whole. The remains of a dead animal, the accidental presence of a small patch of some mineral, or other adventitious circumstance, may cause the analysis to be most misleading, unless proper precautions have been taken.

A very simple method of taking representative samples is to bore holes in the soil to the depth of, say, a foot and a half, with an ordinary auger, and to remove and place in a canvas bag all the soil that clings to the auger. When ten or a dozen of such samples have been taken in different parts of a field, and well shaken together, the bulk sample is generally fairly representative of the whole and not so likely to mislead an analyst.

It is well, however, that planters should be able to make some simple and yet very informative tests for themselves. Acidity of the soil can be easily detected by the use of small pieces of litmus paper, which can be obtained from any chemist for two or three pence. This litmus paper is manufactured by dipping a specially-prepared paper in a solution of litmus. It has the peculiar property of turning to red when in contact with acid. If the litmus paper is inserted into the middle of a handful of soil and turns red, it is a sign that the soil is acid. The acid might be the harmless carbonic acid always present in the soil, but in that case the carbonic acid would volatilize as the paper dried. If the paper remains red when dried it is a proof that the soil contains fixed acids or acid salts and should have an application of lime to correct the fault.

Hydrochloric acid is constantly used by agricultural chemists in testing for the presence of lime in the soil. If, when a few

FIG. 68.—View showing Weeds heaped in Lines on gentle slopes to stop Wash of Soil.

drops of hydrochloric acid are poured on to a handful of soil. there is a foaming or effervescence, that is a sign of the presence of calcium or magnesium carbonate. If no foaming or effervescence takes place it is evident that lime is not present, at least in the form of carbonate.

The tests employed by analytical chemists in analysing soils are, of course, more complicated and more exhaustive. The soil is generally ignited to determine by loss the amount of humus and combined water and part is also treated in solution with various acids to detect the presence and the proportions of nitrogen, phosphorus, potassium, magnesium and calcium, etc., and to indicate what deficiencies should be supplied. A deficiency of any of these chemical elements always manifests itself in poor and backward growth and in liability to disease. The benefits of manuring are founded on the axiom that no great abundance of the general elements of plant food can compensate for a deficiency in one remaining important element.

Of recent years there has been quite a change of opinion and practice in more advanced circles interested in agricultural chemistry. While at one time it was generally accepted that the requirements of any cultivation as regards manuring could be definitely ascertained by means of a chemical analysis of the soil, this is not now believed to be correct. The necessary elements may be present in the soil, and this may be certified by means of chemical analyses, but they may not be " available." This is to say, they may be locked up in a sufficiently insoluble form. Instead, therefore, of the strong acids hitherto employed in testing the soil, which broke down all opposition and released locked-up elements, it is now more commonly the practice to employ quite a weak solution of citric acid as a test of what amounts of phosphoric acid and potash are present in the soil in a form readily " available " (easily soluble). If a weak solution of citric does not bring evidence of the presence of potash and phosphoric acid, they are not present in the soil in a form " available " to the roots and the bacteria present in the soil.

As a matter of fact, here again with regard to what should be applied to land in the form of manures there is a great deal of obscurity and indecision. Like the managers who chose about a dozen different planting distances on their estates in the hope that at least one would be right, so, in the matter of manuring, a frequent principle upon which the manures are supplied seems to be to put in something of everything and it will surely do.

Of the substances which may prove deficient and therefore need to be supplemented by manures or treated to be made "available" there are three and three only, except in exceedingly rare and extraordinary cases, which require attention. These are nitrogen, phosphorus and potassium, the two latter being generally referred to under the name of their oxides as phosphoric acid and potash. It is true that lime (calcium) is sometimes, nay, frequently, deficient, but in the true sense lime is not so much a manure as an agent which assists in making "available" the stores of the above elements locked up in the soil in a more or less insoluble form. The lime has also the use of keeping down soil acidity and so encourages the beneficial bacteria and gives the roots healthy conditions.

There are thus three special classes into which manures are generally divided: manures to supply nitrogen, to supply phosphoric acid and to supply potash. In addition, there are the manures which are a general admixture of the foregoing. Now it may be stated that an atom of nitrogen is one of the most active and powerful things in existence. There is a restlessness about an atom of nitrogen which makes it ready to fly off on the slightest pretext from the body with which it was united and to combine with another. The carbon constituents of a tree are the mere framework or skeleton, but the moving, working, vital thing in the protoplasm of the cells which brings about the continuous adjustments necessary to the existence of life is nitrogen.

Nearly four-fifths of the atmosphere is composed of nitrogen gas, and every square yard of the globe's surface has pressing upon it nearly seven tons of nitrogen. This is what is called "free" nitrogen. It is known that flashes of lightning will cause the nitrogen and oxygen of the atmosphere to combine in its path to form nitric oxide and other oxides of nitrogen that are swept down into the soil by rain. The bacteria in the nodules of leguminous plants also are able to fix "free" nitrogen. The quantities, however, extracted in such ways and added to the general stock of "fixed" nitrogen are but small. Were it not for the constant "fixation" of immense quantities of free nitrogen from the air by bacteria, living in the soil itself, vegetation would be scant indeed and the animal world, including mankind, could not exist.

As a matter of fact agriculturists in both Europe and America depend largely for the necessary fertilizers to produce their crops of grain on the nitrogen present in the nitrate deposits of Chile. When these are exhausted, as they will be in about twenty years, starvation may stare the world in the face unless the large electrical establishments now at work in Norway, Germany, Italy and the United States, endeavouring, with some success, to fix free nitrogen from the air, can enormously increase their output.

One of the most successful companies engaged in this work is the Societa Italiana per la fabbricazione di proditti Azoti, of Rome. They have now put into the market calcium cyanamide under the name of "kalkstickstoff," a fertilizer rich in nitrogen, and Dr F. Löhnis, of Leipzig, as the result of careful experiments, has been able to show that bacteria alter it and produce at a greatly-increased rate food for plants.

Briefly, the manures which up to the present have been in demand to supply nitrogen are nitrate of soda, sulphate of ammonia, nitrate of lime and such substances as oil-cake, rape meal and blood meal. To make up deficiencies of phosphorus, superphosphate of lime and basic slag are most in demand, and crushed bones or bone-meal are also used, but are expensive and not so beneficial. Expense also prohibits the frequent use of large quantities of phosphatic or fish guanos. The commonest form of a potash manure is the substance known as Kainit, a natural salt containing approximately 22 per cent. of sulphate of potassium and 2 per cent. of potassium chloride.

Just a word of warning about chemical fertilizers might be useful. It is this: frequently one element acts very quickly upon another and their usefulness is much impaired when mixed together and not immediately applied to the land.

The manure from cattle is, of course, of considerable value, but its contents naturally vary according to the fodder upon which the animal has been fed. The liquid portion is the best, being the richest in nitrogenous matter, and should be carefully preserved. If, however, such manure is not produced on the estates, and is scarce and dear, chemical products may be more economical. Where cattle are kept, every effort should be made to preserve the manure, especially the liquid, as an application gives young plants a splendid start off.

In many cases manures, and especially expensive manures, might very well be dispensed with on rubber plantations, even where there is a tendency to backward growth. The backward growth does not generally arise from a deficiency in any of the necessary elements of fertility, but may be due solely to the fact that while present they are not in a form readily "available." In most cases the addition of four or five hundredweights per acre of unslaked lime will greatly benefit the soil. This is not so much because lime is a manure, but because it acts on certain chemical elements and transforms them into a form readily available for plant life.

The beneficial effects of adding lime to the soil are numerous and easily apparent. The lime is of great assistance to the bacteria in converting decaying vegetable remains in the soil into nitrates, the form in which they are immediately "available" for plant food. It has also an action upon the natural silicates present in the soil and liberates from them supplies of potash which the roots of the trees desire. Lime has also a sweetening effect. Where soil is somewhat acid, lime induces an alkaline reaction and thereby promotes high fertility. In the case of heavy clay soil it has the effect of making the soil more easily divisible and coarser, this permitting a freer circulation of both water and air, a very marked benefit indeed. As a simple form of manure, and one which at the same time contains a proportion of lime, and thus yields special additional benefits, basic slag is often very serviceable.

Basic slag, which during recent years has come into general demand for purposes of manuring, is a by-product in the manufacture of steel from pig-iron. The pig-iron contains large quantities of phosphorus which it is necessary to get rid of, and this is effected by blowing air through the molten mass of iron which has been previously mixed with lime. The slag and the lime bricks which line the converter where the smelting takes place are, after the smelting is finished, ground to powder and sold as the phosphatic manure known as basic slag.

There has been a good deal of discussion as to whether rubber trees are benefited by manuring. The following brief remarks may, therefore, be of interest.

When tea is well manured the result is directly seen in a good flush of fresh leaves. When cacao is manured the bush is strengthened and bears more pods of beans and is less liable to be attacked by canker. When coffee is manured the bushes become more healthy and vigorous, there is less disease, and there is a better show of berries. The evidence of the benefits of manure may be less directly visible in the case of rubber, as there are no berries or pods to pluck and weigh, and one does not seek to pick the leaves for manufacture. No one, however, should seek to deny that benefits are to be derived, although disappointment is often expressed at the want of much immediate response in the way of increased girth in trees manured.

The more foliage there is on the tree the more nourishment is available for the growth of the tree, and the more quickly will additional cells be built up and the height and the girth of the tree extended. Although, therefore, it may not be easy to prove that manuring Heveas will directly increase the flow of latex, yet the indirect influences are abundantly apparent. The very fact that it is necessary to give the soil some additional cultivation in order to apply lime or some simple form of manure or fertilizers is a gain.

An ordinary rubber plantation, if it has been established on virgin soil, should not absolutely demand any manuring for very many years. It is different when tea, coffee or cacao are cultivated as inter-crops, or when the soil is naturally poor or deficient in some one of the necessary chemical elements. At the same time there is no doubt but that most soils can be benefited by manuring, and that the trees will show an improved growth thereafter. What should always be aimed at is the very best possible results. No doubt good results can be obtained in the generality of cases without any liming or manuring, but if still markedly better results can be obtained by liming or manuring, then they are distinctly desirable. In manuring, as in many other things, " the liberal hand maketh rich."

One writer on rubber expresses the opinion in his book that " excessive applications of nitrogenous manures are not advisable for Heveas, as they tend to produce too rapid growth and render the trees more susceptible to being broken by wind."

This is a dark saying. Surely it is better to have big trees, and big trees as soon as possible, rather than small trees. A big tree, having a stouter stem, is less likely to be seriously injured by a storm than a small tree is. A soil rich in nitrogen is always to be preferred.

The mistake of putting on too much at a time of strong chemical manures is one which can be made. A moderate application at a time, twice or thrice applied, gives better results. Scientific observers who make and study cultures of various bacteria have noted the fact that while the bacteria thrive well and multiply with rapidity in weak solutions of various salts, strong solutions remain barren.

When applying chemical manures for the purpose of adding to the fertility of the soil it is always well to previously mix them with thoroughly dry and finely powdered earth. By this means a better and more regular division of the chemical manure can be made over the estate, and there is less risk of some areas getting too much while other areas get too little or none. There is also less chance of considerable quantities of valuable material being washed away into drains with the first heavy shower of rain.

Generally speaking, an application of lime is what many soils, especially peaty and clay soils, need most, and this is not expensive to procure. In the Federated Malay States and Straits Settlements the cost of one ton of lime and its application to an acre is usually about $20. Unslaked lime is best. With green manures either lime or basic slag, added to the soil a month or two before or after rather than at the same time, answer excellently, correct any sourness in the soil and greatly add to its fertility. What light gravel or sandy soils most require is green manuring to add binding power to the soil particles and thus assist the capillary action elsewhere discussed at length. Where canker is prevalent, or burr-like growths troublesome, potassium is stated to have markedly beneficial effects.

CHAPTER XXXIV

RAINFALL

A GOOD rainfall is of the utmost importance not only for the growth of the rubber trees but if one is to have first-class yields of latex later on. Water is necessary for the health, the growth, the existence of the Hevea. A tree promptly droops when the water contents of the cells are reduced. Instead of the stems being erect, and the leaves fresh and green and spread out to the light, the stems weaken and the leaves turn brown and shrivel up. Not only does water serve the purpose of dissolving the salts and other elements necessary for the nourishment and consequent growth of the tree which it receives in solution through the roots, but the tree needs the water itself, and may be as truly said to drink it as any animal does.

The circulation of water from the soil through the roots of the tree, thence through the sap-wood cells up to the leaves, and thence discharged into the air, is called the transpiration current. Given a sufficient rainfall, the roots of the tree supply it with water as fast as the leaves discharge it into the atmosphere; but when the rainfall is insufficient and the soil parched and dry the leaves give off more than they receive, the sunlight shrivels them up, and they wither away. The stomata of the leaves can prevent only a certain degree of loss of water. The leaves cease to be able to convert the carbonic acid gas derived from the atmosphere into carbon compounds, to work it up into sugars and starch, and the growth of the tree ceases for the time being.

The bacteria in the soil require moisture as well as air to carry on their work, and when the soil is dry, caked and hard, then activities cease. The roots of the tree suffer as well as the foliage during a continued drought.

Obviously, the larger the area over which the roots of a tree spread the more widespread are the available sources of supply. Stiff, uncultivated soils hinder such free expansion of the roots as is eminently desirable for the welfare of the tree. So does close-planting. Manuring freely does not make up for this want of room. No matter how much plant-food there is, it can only be absorbed in a state of solution. The policy of close-planting and freely manuring advocated by a well-known planter seems thus based on a misunderstanding of the conditions of plant life.

The rainfall varies in many districts in a most surprising manner. In the case of neighbouring plantations, one estate often seems unduly favoured and the other neglected. In times of drought, when rain is very much needed, it is galling to see showers pouring over neighbouring estates and ceasing just at the edge of one's own plantation. Yet this is a common occurrence on many estates.

Rainfall returns should be most carefully kept, and the records for past years should be always available. These are a useful guide to estate managers, informing them of the months in which a good rainfall can be reasonably expected, and in what months rainfall is scant and precarious. The prudent manager will not set about his planting-out during the months when a sufficient supply of rain is doubtful.

Where an estate has any inter-crops planted, or where it is proposed to plant inter-crops, the rainfall records should be first consulted. On certain estates in East Java, for example, one sees certain estates with cacao as an inter-crop. Had the rainfall records been first consulted, a wise manager would not have planted cacao on these estates. The rainfall is insufficient, and sometimes it is unseasonable. Hence some of these estates have never had a really good crop of cacao.

Eighty inches per annum is about the smallest amount consistent with the welfare of a rubber plantation. Ten inches more rainfall are a very valuable asset, and other 10 or 20 inches still better. Light, porous soils and a scanty rainfall mean poorly-grown rubber and small returns of latex. Heavy, clay soils withstand droughts longer and better, but need more tillage.

Where the surface of the soil is caked and hard the greater portion of the heavy showers of rain flows off immediately into the drains and is lost. In such a case a rainfall of 80 inches per annum may mean that the rubber trees get the benefit of only 45 to 50 inches, as the most of the rain promptly finds its way into the drains. In such cases, breaking up the ground by chankolling it over is followed by immediate benefit to the trees. For all practical purposes the rainfall is thus at once doubled, or nearly doubled. Chapter and verse could be cited of estates where this has been found to be the case, but it is not always advisable to give names.

One inch of rainfall on 1 acre of land represents 3630 cubic feet of water. When, say, 5 inches of rain fall during the course of twenty-four hours, as is not very uncommon, there is a very large volume of water to be discharged. There are, of course, in certain districts in Ceylon and India, occasions where the rainfall is as high as 18 inches in twenty-four hours. Taking, however, a more ordinary rainfall, such as 5 inches in twenty-four hours, the rivers of water that result are a severe test of an estate's drainage arrangements. On a hilly estate, unless very well terraced, or protected with belts of grasses and the growth of light weeds, the wash of surface-soil is very great. On a flat estate, unless well drained, the flooding which ensues may involve wading for a week.

The effects of a rare, occasional flood on a low-country estate generally soon pass off without much damage being done, but a constantly water-logged soil is ruinous to rubber.

Rainfall records should not only state the amount of the rainfall on each day of the year, but whether the rain fell during the forenoon or in the afternoon. A heavy rainfall during the early hours of a day means the loss of the day's tapping. In the afternoon a heavy continued shower does not interfere with this work. In this way the average number of days available for tapping during the year may be ascertained and checked.

CHAPTER XXXV

DISEASES

LIKE other living organisms, plants and trees are liable to the attacks of diseases. When carefully examined, these diseases are found to be not altogether dissimilar to those by which the animal kingdom is affected. Animals suffer from lung diseases, and the breathing of plants may also suffer and be seriously affected by unsuitable conditions. Canker attacks trees as well as animals. Unhealthy growths afflict many animals, and plants suffer in the same way. The blood of animals and the sap of trees can both become poor and anæmic. Fungi and bacteria are the sources of many diseases in both the animal and vegetable kingdom which are constantly being investigated by new methods in science. Trees, like animals, are subject to such accidents as broken limbs. Poisons have evil effects on all kinds of animals and all forms of vegetable life. When one comes to regard trees as living beings with an intelligence all their own, then one can better comprehend the nature of the diseases from which they suffer and how they combat them.

The chief sources of infectious disease from which trees suffer are the fungi and bacteria. While the ordinary members of the vegetable kingdom generally derive from air and water and soil the nourishment necessary for life and growth, the fungi, which occupy so considerable a place in the vegetable world, feed, like animals, on already-formed organic substances. Injured or unhealthy trees are always most readily attacked.

Professor Erikson, a Swedish botanist, has devoted long study to fungoid diseases and gives it as his established conviction that year by year the diseases of cultivated plants become more numerous and disastrous. It is stated that parasitic fungi, which hitherto have proved almost harmless, have changed their nature and become most destructive. It is true that much

FIG. 69.—A Tree which has Fallen Down as the Result of Fomes attacking the Roots.

more strict attention and discriminating investigation are now given to plant diseases than ever in the past, and thus hitherto unnoticed diseases are tabulated. But Professor Erikson says while that is so, what are undoubtedly fresh fungoid diseases have recently appeared in various countries. This is accounted for by the fact that cultivation of great masses of any particular plant generates new characteristics in individual plants and

Fig. 70.—Illustration showing Lace-like Films of Fomes on Roots of Fallen Tree.

Fig. 71.—Illustration showing Fructification (Spore-bearing Organ) of Fomes.

(Both Photos by Mr Richards, Mycologist, Caledonia Estate, Straits Settlements.)

some of the new forms are from their nature more liable to disease and in their turn may affect a whole plantation.

Although Professor Erikson's investigations have been confined to countries in temperate regions, and do not include the Tropics, yet the dangers are greater there.

In the case of rubber cultivation the numbers of the trees of one species, the *Hevea Brasiliensis*, which have been planted are so vast as to render them specially liable to attack. The dangers likely to arise from an epidemic have been often pointed out by Mr Herbert Wright and others. So far rubber plantations have escaped epidemics like the coffee blight, which swept the coffee plantations of Ceylon out of existence. This, however, may not be always the case, and it behoves every planter to see that his estates are kept in a thoroughly good state of plant sanitation. Sound health is an essential if trees are not to be very readily liable to attacks of fungoid diseases, and over-tapping and close-planting and want of cultivation undoubtedly mean that trees are in a sickly condition. This is a very grave danger. Estates are often too large and generally much too close together. In Sumatra this is especially the case, as plantations extend great distances almost without break or interruption. A few planters have disease belts a few yards wide to divide off their estates, but such meagre precautions would be of no avail.

On the first sign of any important outbreak it would be well if the Government of the country would order the whole plantation affected to be felled and the timber thoroughly burned. Once an epidemic spreads—if one should ever occur—only immediate and heroic measures would be of any avail. It is to be hoped that there may never be any necessity for such measures, but there is so much capital now invested in rubber cultivation, and the results of an epidemic would be so far-reaching and disastrous, that the possibility should be contemplated and the nature of the immediate action to be taken decided on by local Governments *now*.

The fungoid diseases which attack Heveas may be divided into three classes, namely: those which attack the roots, those which attack the stem, and those which attack the branches.

Of those which attack the roots of the Hevea the best-known is *Fomes semitostus*. Wherever there are decaying roots or large pieces of timber left on the soil, evidences of the existence of this pest are sure to be found. From the decaying timber it spreads with the greatest rapidity and attacks the roots of healthy trees. The losses caused in this way are often very serious. Where young trees have been planted on recently-felled jungle-land from which all the roots of the former trees have not been extracted, the ravages caused by Fomes are sometimes appalling.

It is found that this is especially the case where the roots of certain hardwood trees have been left in the ground. The roots of hardwood trees have a special affinity for *Fomes semitostus*, and when pieces of them are dug up out of the soil they will invariably be found to be covered with white slime and the thread-like filaments of the fungus. Wherever such roots are they should be thoroughly searched out and no fragments allowed to remain in the soil as a source of infection. Even if financial considerations do not permit a manager to remove all dead timber, roots and stumps, there must be no half measures about the entire removal of the roots of these hardwood trees. Undoubtedly the proper course to pursue is to remove all roots and decaying timber, but counsels of perfection, however excellent, are not always followed.

FIG. 72.—View on an Estate in Siantar, Sumatra, showing Trenches made to Isolate Trees suspected of Fomes.

The apparent connection between the attacks of white ants and Fomes has been frequently commented upon. That there is some connection is not to be doubted, but the exact nature of the connection has not yet been made clear. One point in dispute is: which attacks the roots of the Hevea first—the pest or the disease. The two seem to act as allies in their attacks on the tree community.

It might seem not improbable that spores of the fungus are transported to the roots of the Heveas by the white ants in the same way perhaps as bees and other insects carry away on their heads and shoulders pollen from one plant to another. It is even (although this is improbable) not beyond the bounds of possibility that the white ants spread the spores of the fungus willingly in the hope of profit later on. Far more intelligent and extraordinary artifices than this are credited to other branches of the insect world. Some of them are so extraordinary in the cold-blooded calculation of their Machiavellian designs that they might appear incredible if not well vouched for.

Working in apparent collaboration, or at least almost simultaneously, the attacks of Fomes and white ants can sometimes be exceedingly severe on special areas on plantations and keep managers and assistants on the *qui vive* for years.

The percentage of attacked trees has reached as high as 40 to 50 per cent. on not inconsiderable areas with a heavy resultant mortality, and the financial loss to the company concerned was grievous.

Why some special fields should be singled out for severe assault, and others, with apparently exactly similar conditions as to amount of decaying timber and otherwise, escape, has often been a matter of speculation. The probable cause is that the soil of the affected area is in a more acid condition or in some such way more favourable to the multiplication of fungi.

To some extent this is borne out by the fact that an improvement in drainage has been immediately followed by a marked decrease in the number of cases of Fomes. This is one of the continual instances which keep occurring to testify to the necessity of getting the soil into a good state. When soil is badly drained and uncultivated, and, therefore, unaerated, it is the happy hunting-ground of the maleficent forms of bacteria and of fungi.

Every manager, especially on newly-planted jungle-lands, should employ a number of his most intelligent coolies as assistant inspectors to report on all cases of suspected disease. Their whole time and attention should be given to this work, and nothing should be permitted to interfere with it. The signs of disease are usually a listless look about the foliage and hanging down of the leaves, and, when the roots of the tree are at all seriously affected, it will be found to be loose in the soil. If badly attacked it can readily be pushed over, or will fall of its own accord. In the latter event the roots should at once be dug out, the soil treated with lime and exposed to the sunlight.

FIG. 73.—Making Trenches round Trees attacked by Fomes, and Disinfecting with Lime.

When a suspected case is reported, the roots should be well exposed, and, if the tree is found to be affected, the roots should be thoroughly well washed over with lime and a trench dug all round to isolate the tree. Wherever a case of Fomes occurs the trees in the immediate neighbourhood should also be treated

FIG. 74.—Illustration showing New Branch growing from Tree Topped on account of Pink Disease.

in the same way. When taken in time trees can nearly always be saved. Those very severely affected are best out without delay, and the soil should be thoroughly disinfected before a new plant is put in.

Pink Disease (Corticium Javanicum or Corticium Salmonicolor, known in Java as " Djamoer-œpas "), which attacks the stems of Heveas, is not nearly so common as Fomes, but is yet, unfortunately, by no means rare. It usually makes its first appearance at the junction of branches, or at the forks of trees. On one well-known Java estate, where it was unusually preva-

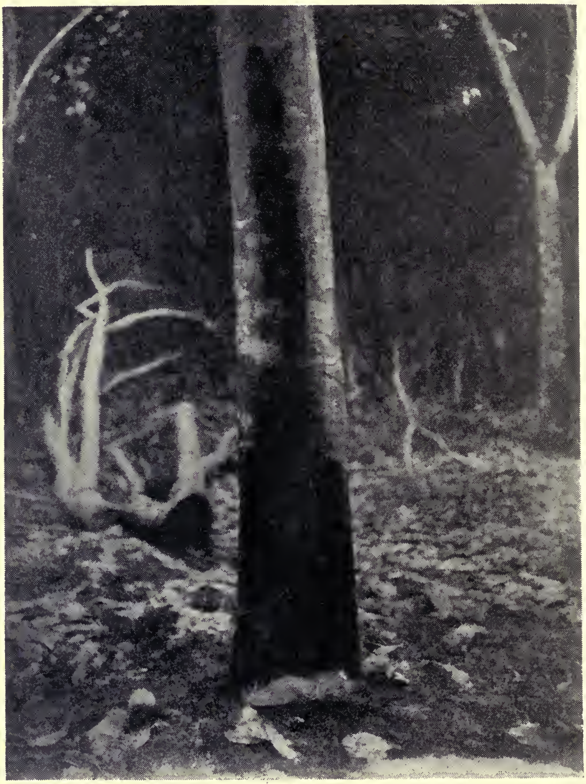

FIG. 75.—Case of Diplodia observed through the Appearance of the Bark.
(Photo by Mr Richards, Mycologist, Caledonia Estate, Straits Settlements.)

lent, all the forks of the trees, where water could possibly lodge, were well tarred as a preventive measure.

Excision of the diseased portions of the bark is the only remedy, and after thorough excision the portions where bark has been removed should be well tarred. It should not be taken for granted that the excision has proved a remedy. The

FIG. 76.—A Case of Pink Bark Disease.

tree should be visited again from time to time, to make certain that all danger is past. In Sumatra planters had noticed that pink disease was especially prevalent amongst rubber trees interplanted with Liberian coffee. When the coffee was cut out the disease ceased to be troublesome.

FIG. 77.—Burr Growths (Actual Size).

According to a Dutch authority, the typical form in which this fungus appears is a thin, continuous pink sheet which becomes cracked all over the surface and assumes a yellow tint after some time. It also occurs in damp situations, such as forks of trees, in the form of a thin matting of silver-coloured filaments. It is also sometimes found in cracks of the bark in the form of small pads pink in colour. It penetrates into the wood beneath the bark, and cutting away the bark is not always sufficient to eradicate it.

Canker (Phytophthora Faberi) is another fungal disease which attacks the stems of Hevea. It is much more frequent in Sumatra than in the Federated Malay States. It is more common among Heveas when they have been interplanted with coffee or cacao. Its presence is not so easily recognized as is the case with pink disease or Fomes, and often the first and only indication of disease is that the trees cease to yield latex. The use of the knife is the only remedy, and tar should be well applied to the wounded spot. A deficiency of potassium in the soil is often a contributing cause to such disease as this, and after liberal manuring the trees become almost immune.

Dieback (Diplodia theobromæ) attacks are ascribed to fungi bearing a variety of names. The leading shoots, or branches, of the tree are first affected. From these Diplodia sends its threads down through the larger branches, spreading far beyond the portions apparently affected. Very severe cutting back is necessary when the branches of a tree become attacked, and all wounds should be well tarred over. The bark of trees severely attacked by Diplodia has a blackened, sooty appearance.

All cuttings from diseased trees should be carefully burned, as otherwise they will become fertile sources of infection.

Burrs are peculiar excrescences which grow in, or under, the bark of the Heveas. They are not due to fungoid growths, and are not diseases which imperil the health and existence of the tree. Yet they may be extremely annoying and be a great hindrance to tapping operations. As a rule they are quite small at first, but grow and multiply quite rapidly. The use of the pricker is invariably followed by an alarming growth of burrs, which frequently join on to each other, increase in size, and form large swellings round the trunk of the trees. To cut them out is quite a serious operation, and, on old trees originally badly tapped, it often appears almost impossible without sacrificing the tree. Yet if the trees are manured, the soil cultivated, and tapping operations suspended, the growths can often be removed and the bark largely restored.

These burr growths, however, are not always the result of bad tapping; they occur quite frequently on young trees which have never been tapped. They are most numerous on old

FIG. 78.—Young Untapped Tree showing Burr Growths.

cacao or coffee estates which have been planted up with rubber, and where the soil, if not exhausted, is at least lacking in some chemical element necessary to the health of the trees. Where these growths are at all troublesome, coolies should be trained to report them. They are easily cut out when quite small, and

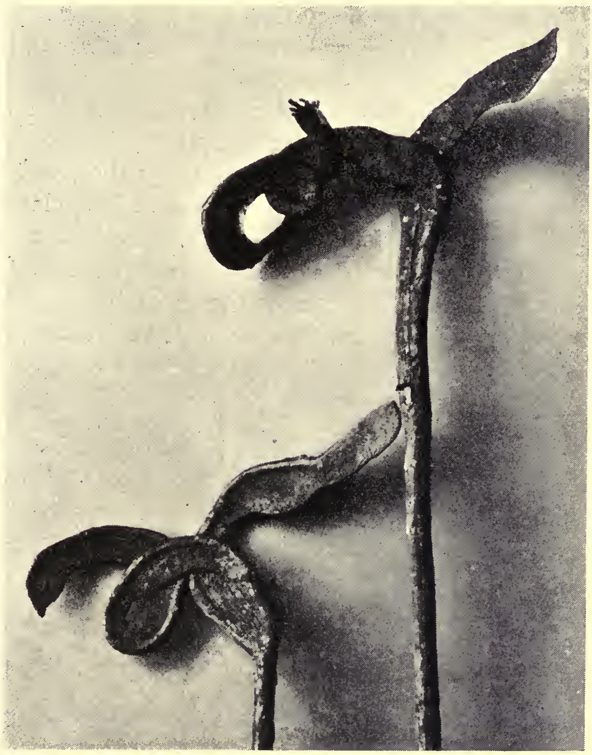

Fig. 79.—Illustration showing Fasciation.

the trees suffer no damage if this is carefully done, otherwise they are apt to grow to a considerable size, join together and greatly interfere with tapping operations.

On many estates where these burr growths occur on untapped trees they are very prevalent on certain areas, while on other areas the trees are scarcely subject to them. There must be some special reason in the nature or condition of the soil to account for this, but as yet the reason is unknown.

It has been reported that, on one estate in the Kelani Valley, Ceylon, the burrs fell out after the trees were well manured. It would be very interesting to learn whether any other planters had a similar experience.

Fasciation.—This is rather an abnormal form of growth than an actual disease. Fasciation is the growing together of a series of stems, or stems and leaves, to form a broad, irregular structure.

The cause of fasciation is little understood. Fasciation is not, like the growths of gall-nuts, caused by insects. It may possibly arise from some injury received by the seed. In the case of trees which bear branches with these irregular growths the tendency seems persistent. Even when all such branches are cut off, the irregular structures appear again. Like the "black sheep" that is the constant grief of the parents of an otherwise respectable family, this is one of the things no fellow can understand.

FIG. 80.—Fumigating White Ants from their Underground Galleries.

CHAPTER XXXVI

PESTS

WHITE ANTS (*Termes Gestroi*).—The common ants belong to the same order of insects as bees and wasps, but the termites, or white ants, are in no way connected with that order. The white ants belong to the same family of insects as the dragon-fly. In a colony or nest of white ants there is a queen who is the parent of her subjects. The subjects are of two classes—soldiers and workers.

White ants are generally the most troublesome pest against which planters have to contend. Naturally, white ants are most troublesome on estates in the close vicinity of jungle, or in cases where there is a good deal of decaying timber lying on the soil. On estates which have been formerly under lalang they are not nearly so much in evidence. If white ants confined themselves to the destruction of decaying timber they might be regarded with complacence, but, unfortunately, this is not the case. Even where there is an abundance of decaying wood they sometimes seem to like a change of diet and to attack healthy growing trees. On this account they have to be kept under close observation, hunted out and exterminated.

For the extirpation of white ants insecticide powders have generally been found of little avail, and fumigation is generally regarded as the only satisfactory method of dealing with them. White arsenic and sulphur, both very cheap chemicals, are found most efficient for fumigating purposes. Five-sixth parts of coarse white arsenic to one-sixth part of flowers of sulphur makes a good mixture. Small machines are to be readily obtained for blowing the fumes into the burrows of the white ants. These burrows, which are often of considerable length, should be traced out up to the nest before fumigation is started.

Mole crickets are troublesome on occasion, especially on estates which have very young rubber. They have been known to clean out quite an extensive acreage of seedlings. All means used to deal with them were ineffective. Such visitations are rare, and are only to be dreaded in the case of newly-planted areas.

Boring beetles (Xyloborus, etc.) sometimes cause annoy-

FIG. 81.—Tree attacked by Boring Beetles (Xyloborus), showing excavated Wood Dust on Stem.
(Photo by Mr Richards, Mycologist, Caledonia Estate, Straits Settlements.)

ance, but although one cannot afford to neglect them, cases are not very numerous as a general rule. There have, however, been a few instances in which large numbers of them have appeared on a plantation and done sufficiently serious damage. One such case occurred in Java a few years ago. Disinfectants, excision of bark, and smearing with tar were found to be useless.

FIG. 82.—An Old Tree on Sungei Roean Estate, Sumatra, attacked by Boring Beetles.

Ultimately the worst-affected trees were cut down and burned in order to prevent the pest increasing when the eggs the insects had deposited in the wood of the trees were hatched out. While many planters have asserted that only dead or dying trees are attacked by these beetles, the facts undoubtedly point the other way. The illustration given of an attacked tree which shows the latex freely escaping from the holes made by the beetles proves this, and so does the experience of several well-known managers.

Wild pigs are more troublesome in Java than anywhere else, and several estates have had to spend a good deal of money on the erection of substantial fencing with eleven strands of wire to exclude them.

Monkeys and deer are ubiquitous, but, although troublesome, can be kept under, and the damage that they do is seldom very extensive. Porcupines do a lot of damage among seedlings in Ceylon, and the only way of dealing with them is to keep plenty of watchmen with guns on the lookout at nights.

In Samoa, and to a smaller extent in Sumatra, rats have been found to be exceedingly troublesome on many rubber estates and have done great damage. The writer has seen cases where young plants have been so badly gnawed that replanting has had to be done over considerable areas and the seedlings and stumps protected against further attack. Zinc cylinders on the joints of bamboos have proved an efficient protection in such cases, and made planting, previously more than precarious, possible. Such attacks are most troublesome and most difficult to check on estates which are not kept in a clean weeded condition.

CHAPTER XXXVII

INTER-CROPS

GENERALLY speaking, there is no doubt that, if one wishes to grow the best possible rubber trees, a rubber plantation ought to be a rubber plantation all the time and without any catch or inter-crops.

The distinction between catch-crops and inter-crops consists in the fact that inter-crops, such as tea, are intended to be more or less permanent, whereas catch-crops, such as tapioca, on the other hand, are only intended to occupy the ground for one or two years at most.

Catch-crops, such as tapioca, indigo, ground-nuts, pine-apples, gambier and hemp, have gone largely out of favour, as it has been found that the profits attaching to them are of a very illusory description, after the expenses of factories and machinery for the purposes of manufacture have been met. These press heavily upon income when only one or two crops at most are possible. Then, too, it has been fully recognized that hemp, pine-apples (which are a species of hemp), gambier, and tapioca are crops which are exceedingly exhausting to the soil.

In Singapore Island, for instance, owing to the blessings of settled government, a large native and Chinese population has long been settled, and the ground has been cropped and re-cropped under tapioca, pine-apples and gambier for many a long year. Even at the present day one can see on several estates pine-apples between the rows of rubber trees. As a consequence the rubber trees are extremely backward for their age. In acreages on the same estates, where the pine-apples have been removed and the ground dug over, the rubber at once responds. On some estates the coming into bearing of the rubber is delayed two and possibly three years by the continual growing of this catch-crop. Profits from pine-apple growing have been much reduced of recent years, and any meagre margin of profit derived from the pine-apples has been dearly procured at the expense of delaying the rubber.

The principal inter-crops in favour are tea, coffee and cacao.

Tea.—The growing of tea between the rows of rubber trees is almost unknown except in Ceylon and Southern India, where it is a common practice. . Where rubber is only planted along roadsides and drains there can be little objection to its presence. In cases, however, where the tea is interplanted throughout the rubber, the growth of the rubber is somewhat hindered by the roots of the tea bushes occupying the ground. The rubber, however, suffers somewhat little as compared with the tea, which, when it becomes heavily overshadowed by the rubber, suffers severely, and soon becomes unprofitable to cultivate. As the cultivation of tea involves the installation of an expensive factory and machinery, the two do not grow well together, unless the rubber is very widely planted.

Coffee.—Coffee has for many years been a favourite inter-crop with rubber. Indeed, as coffee was on the scene, especially in Java and Sumatra, long before rubber came along, it is perhaps hardly a correct description to call coffee an inter-crop. In many cases the rubber was interplanted as a venture, in the midst of going coffee plantations.

Arabian coffee, Liberian coffee and Java coffee were, until within the last few years, the varieties most cultivated. Within recent years Robusta coffee has come to the front. When cultivated on virgin soil this coffee gives astonishingly large yields. As its name implies, it is a hardy plant and is not subject to anything like the same amount of disease as, for example, affects Java coffee. In addition, being more hardy, it is not so much affected by adverse climatic conditions, and one has not to fear crop failure, so common with Java coffee. In Java this coffee is usually grown under the shade of lamtora, in addition to the shade which it obtains from the rubber in which it is interplanted, but in Sumatra it is grown without any other shade than that supplied by the rubber.

If it is proposed to plant, say, Robusta coffee as an inter-crop, the rubber trees should be very widely planted, and in this way the objection to inter-crops may be lessened. Later on, if and when the coffee is cut out, the rubber trees would be found to have secured the advantage of wide planting. The chief objection to the presence of either Robusta coffee or Liberian coffee as an inter-crop, even when the rubber is widely planted, is the fact that both Fomes and pink disease are somewhat more prevalent among the rubber where it is interplanted in this way than on areas which are not interplanted with coffee bushes. This has been the general experience of planters in Sumatra.

Cacao.—Cacao is, perhaps, the most objectionable of all the inter-crops mentioned here. It is rare indeed to see a plantation where the cacao bushes are not seriously affected with canker. Add to this the fact that cacao is subject to attacks of Fomes, and it will be realized that its presence in the midst of a rubber plantation is most undesirable. Apart from these objections cacao is dependent on rain, and abundance of it, at exactly the right season, so that it is generally an extremely unprofitable crop to cultivate. Cacao requires very heavy shade if the bushes are to fruit well. The shade given by rubber trees is not sufficient for this purpose, and large shade trees, such as dadaps and Albizzias, have to be grown. The roots of these trees take up a great deal of room and hinder the expansion of the root-systems of the Heveas. Further, the heavy shade afforded by these trees is found, in practice, greatly to retard the growth of Heveas. The usual result in practice is that, by trying to make conditions suit both cultivations, both the cacao and the rubber are poor in appearance, and sooner or later one has to decide on cutting out one or other of these cultures.

Coconuts and rubber should never be interplanted. If they are, both suffer, and one or other has eventually to be cut out. The writer has seen many cases of such interplanting, and in every case the inevitable result was that, sooner or later, and better sooner than later, one or other had to be cut out, and the digging-out of the roots was not accompanied without cost.

CHAPTER XXXVIII

OBSERVATION TREES AND CENSUS RETURNS

On most well-managed estates it is now the custom to select and set apart representative rows of trees on various areas. These areas should contain trees of all the different dates of planting. The trees selected are always marked in some distinctive manner, as, for example, with a circle of red paint. A letter—A, B or C, etc.—is also painted on the first tree next the roadway in each observation row, and the trees in each row numbered in sequence.

Measurements of the girth of each tree are taken at a height of 3 feet from the ground every three months and entered on the observation sheets, copies of which should always be sent home to the head offices. The increases in girth should be always carefully noted and compared with the figures for the preceding three months. One-year-old trees are seldom measured in this way for girth. It is generally found that it is the young trees of 10 to 15 inches in girth, 3 feet from the ground, which show the greatest average increase in girth. Such trees, in the Federated Malay States and in Sumatra, generally show an average increase in girth of quite 1½ inches every three months. Many add 2 inches or more to their girth during three months. Trees of 18 to 22 inches in girth, 3 feet from the ground, usually add only about 1 inch to their girth during the same period.

These are normal figures for normal trees. Loosening the soil all round the roots by digging speeds up increase in girth very markedly. Under such circumstances young trees have added 2½ to 3 inches to their girth within a period of three months. This is just another proof of what cultivation can do to improve an estate.

When trees are being tapped, the tape, being passed round over an excised area of bark, may sometimes give a measurement the figures of which give rise to misleading comparisons, and this is a fact which should not be lost sight of. When it is found that during two successive periods of three months there has been no increase in growth in certain trees, or the increase has been practically *nil*, it is quite time that such trees should be inspected to find out what is wrong. Such cases regularly occur on good estates where the general growth is excellent. They probably would pass undetected for a long period if observation sheets were not kept and carefully scrutinized and compared with those of preceding three-monthly periods. It ought to be considered one of the duties of a secretary to make such careful scrutiny and to draw attention to such cases.

Census returns should be prepared of all the trees on estates. These should detail the total number of trees of each planting age. On all junior estates the census should be also supplemented by one equally valuable, giving the total number of all trees 6 inches and under, 3 feet from the ground; the number of all trees over 6 inches, 3 feet from the ground, and under 10 inches; the number of all 10 inches and over but under 15 inches; the number of all trees 15 inches and over but under 20 inches, 3 feet from the ground, and so on. The details, of course, vary greatly with the different conditions of affairs as to dates of planting on different estates.

Such figures serve as a splendid guide to boards of directors as to when the trees should come into the tapping-round and when and what crop returns may reasonably be expected.

All such data are essential to the good management of a company's affairs, and should never be neglected. It is only a board of amateur directors that would not consider them essential and keep themselves conversant with all the details.

Methods of taking such a census are many and each manager usually has one of his own. Such work, however, should never be entrusted to natives without the most watchful, constant and careful supervision on the part of the manager and his assistants, and any apparent discrepancy on any area should at once be checked. When taking such a census a rod exactly 3 feet long is nearly always used to indicate exactly, beyond the possibility of mistake, to the coolies the height at which girth measurements should be taken.

CHAPTER XXXIX

BUNGALOWS, COOLIE-LINES AND FACTORIES

BUNGALOWS.—The manager's bungalow ought, preferably, to be in a central situation and always in close vicinity to the factory. The advantage of this is obvious. No manager worthy of the name would entirely delegate the work of manufacturing the rubber in the factory to any assistant, no matter how capable the assistant might be. It is a great matter, then, to have the factory close to the bungalow, as, on the way out in the morning to have a round of the estates, a short call can be conveniently made, and on return it is easy to look in for a moment and to see that everything is going on well. The factory is also a central situation for having the roll-call in the mornings, and from that point of view, again, it is well to have it near the manager's bungalow.

The bungalow should be well built in a permanent fashion with cement flooring below, even when it is elevated from the ground, and a cement drain should run round it outside. The posts, if of timber, should be mounted on cement pillars to prevent rotting and—to some extent—to lessen the danger of attacks by white ants. Generally it is better to have all the skeleton of the edifice of iron or steel, as it is very difficult, indeed, otherwise to prevent white ants from bringing down the building sooner or later.

Mosquito-proof rooms are almost an absolute necessity in certain districts, otherwise, after hours, at certain times of the year, the bed is the only place of refuge from incessant and annoying attacks and accounts and reports are apt to fall behind.

There should be at least a couple of spare bedrooms in every manager's bungalow, a good sitting-room, and a verandah where the manager can enjoy the cool of the evening after a hard day's work, when the mosquitoes are not too virulent in their onslaughts.

Galvanized iron roofs are much too hot, and if used there should be an under-ceiling of wood. Bathing accommodation is essential. W.c.'s and kitchens are generally outside buildings and must be connected by covered-in passages.

Assistants' bungalows need only one spare bedroom, but otherwise correspond with the above, but on a smaller scale.

A few flowering plants help the appearance of a bungalow, but the border of empty beer bottles turned upside down sometimes to be seen is apt to cause a wrong impression.

Coolie-lines.—The coolie-lines ought in nearly every case to be of a permanent or at least semi-permanent description. In Java this is seldom the case. The kampongs, as the lines are called there, are generally of the lightest possible construction, the walls being simply mattings of woven bamboo.

Cement floors and a good cemented drain, with an incline running round the lines, are necessities whether lines are to be permanent or not. It is economy to use steel frames and to put up good buildings at the very commencement, otherwise, after a time, there is a frequently-recurring bill for repairs. It is a good thing to have the various rooms in the lines separated from each other above the partitions by strong wire-netting. This prevents any coolie who has been shamming sickness from climbing over the partition and pilfering from his neighbours. Rows among the coolies arise from such things as this.

Perhaps the best system of Javanese coolie-lines is that to be seen on the estates of the Eastern Sumatra Rubber Company. There each family of Javanese has a little cottage with a narrow strip of garden. In consequence the Javanese are very much contented. They keep their houses and gardens quite tidy, while in ordinary cases the services of sweepers are necessary. In all cases all refuse should be deposited only in pits dug for the purpose. The refuse should be buried every now and then, but not too deeply, or it will be too deep for bacteria to act upon it vigorously and will take years to rot away. A mistake is often made in this respect.

Coolie-lines should be well lime-washed at least once every six months inside and outside. The lime-washing is a grand disinfectant, and gives an opportunity for a good clearing up

FIG. 83.—Views of Coolie-lines and Cottages, with Gardens, on Eastern Sumatra Rubber Estates, Limited.

—which is always much needed—to the great benefit of the general health of the labour force. Many managers may grudge the trouble of seeing that this is regularly done, but it is really well worth while.

The cost of coolie-lines necessarily varies according to the manner in which the work is done, the materials employed, and the number of rooms in the lines, and whether the lines are double or single ones. It is not wise to have more than twenty or at most thirty sets of rooms in one line, as fires are by no means infrequent occurrences, and lines are better set well apart. Four to five coolies usually live in one room 12 feet long by 10 feet wide, so that it is a simple matter to count the number of rooms required for any labour force, bearing in mind that Klings, Javanese and Chinese need separate lines or the ladies will raise trouble.

Double coolie-lines cost less per head than single lines. All-wood lines cost less than lines erected of iron and timber, and all-steel lines are most expensive, but may last for about 100 years. For good permanent double lines of not less than twenty rooms the cost per coolie, five to the room, works out in Ceylon at about £2 to £2, 10s. per coolie. In Sumatra the cost would be £3, 10s. per head, and in the Federated Malay States and Straits Settlements £4 per head, although on occasion up to £5 per head has been spent for specially well-finished lines. If single lines are erected the cost per head would be increased by about 10s. in each case. The cheaper class of lines put up in Java work out at £1 to £1, 15s. per head. All coolie-lines ought to have a ventilator on the ridge of the roof over each pair of rooms. There should be a fairly broad verandah in front of the rooms, say, 10 feet wide, to permit of the coolies doing their cooking with comfort, or otherwise cooking sheds should be provided. The eaves should come well down over the verandah to give shelter from the weather.

When the coolie-lines are built up on posts 6 feet from the ground, then the coolies do their cooking underneath the lines. In such cases the soil ought to have a flooring of cement, otherwise, owing to the uncleanly habits of the coolies, it will soon become foul and a cause of disease. A line of this sort, consisting of from 12 to 16 rooms, built up on timber posts set on stone or cement pillars with plank weather-boarding and attap roofing, costs only some £50 per room. The economy, however, is not so real as might appear, as the life of such lines is estimated at only about five years.

Factory.—The factory should be central in its situation and in the vicinity of ample supplies of water for manufacturing purposes. Care should be taken to make certain that, whatever the source of the water supply, it will not fail in time of drought. It is, therefore, unwise to depend upon small streams.

The factory must be a well-constructed building on permanent lines. The floor must be of cement, and of good cement which will not break up under the weight or the strain of the engines or the mills. The factory building should be of sufficient size to allow for all possible extensions of machinery. Galvanized iron, if used for roofing, makes a very hot factory, and if it is used there ought to be a wooden ceiling under it. It is frequently best to purchase factory buildings from some large local engineering firm, or through local agents, and to put upon them the responsibility of erecting the engines and machinery and delivering everything in good running order. This saves a lot of trouble and divided responsibilities. When one firm erects the building and puts down the cement floor, and another firm supplies the engines, and a third the mills, it is not by any means easy to place the blame for anything wrong. This is got over by contracting with one firm who then cannot evade responsibility. The windows of the factory should be either of red glass or have red blinds to prevent the sunlight affecting the rubber. If there is an upstairs flat in the factory a small hand-worked hoist is a very great convenience in transporting goods or rubber to the flat above.

A proper plan ought to be laid out whereby the engines and machinery are laid down in one straight row along the length of one side of the factory, next the windows, with just sufficient passage-room behind them for oiling and the removal of parts for repairs. The engines should be in the centre of the row of mills and directly connected to the shaft without belting. This system saves a lot of room and the loss of power which the use of belting always involves. It also leaves the whole of one side of the factory for coagulating and other operations.

Just facing the front of the mills, and about a yard and a half away, should be cement mounds covered and faced with white-glazed tiles, on which the coagulated lumps of rubber should be laid ready for the mills, and on which sheets of rubber as manufactured can be deposited for the moment. In this way the coolies attending to the mills do not need to leave them for supplies or to remove sheets, and a considerable saving of time is effected.

CHAPTER XL

VALUATION OF ESTATES

THIS is a very difficult matter to adjust satisfactorily, and it is seldom that one finds two managers or visiting agents who agree on all the details. The general plan is to work on six or seven years' valuation of the probable crops. The example given herewith of the estimated crops of an estate in the Federated Malay States or Sumatra shows how this works out. If the estate is situated in Ceylon no crop should be estimated on till the fifth or sixth year.

In this valuation of the crops of a rubber estate, planted on an average with 100 trees per acre, a scale is given of the average crop return during seven years from trees, the youngest of which are one year old. Extensions are not allowed for, being done at cost of purchaser.

CROP RETURN

Age of Trees	1 year	2 years	3 years	4 years	5 years
Year	lbs.	lbs.	lbs.	lbs.	lbs.
1st	nil.	nil.	nil.	50	100
2nd	nil.	nil.	50	100	200
3rd	nil.	50	100	200	300
4th	50	100	200	300	400
5th	100	200	300	400	400
6th	200	300	400	400	400
7th	300	400	400	400	400
Total crop per acre for 7 years	650	1050	1450	1850	2200

The valuer can take the selling-price of rubber for each succeeding year, for the purposes of his valuation, at such figures as seem to him most likely to be realized. It is always well to lean to the side of safety in arriving at final figures. Some take an optimistic view, others a pessimistic view, of the future of prices, and truth generally lies between extremes.

When endeavouring to arrive at the valuation of an estate there are many other factors besides the future selling-prices of rubber to be taken into account.

Rainfall should never be lost sight of. An estate with 100 inches of rainfall—all other things being equal—is worth much more than an estate with nearly 80 inches of rainfall per annum. The crops harvested from rubber in bearing from the estate with 100 inches of rainfall per annum will be at least 50 lbs. per acre per annum higher than from the estate with only 80 inches of rainfall. Rainfall records should, therefore, be consulted. Virgin soil is worth very much more than land formerly cropped with gambier, tapioca, coffee or cacao, but this fact seems to be often overlooked.

Flat land, if not too low-lying, is always worth more than land where there is a constant wash of soil to be guarded against. If an estate is weedy with lalang or other bad grasses, at least £5 per acre ought to be deducted from the valuation. If very bad, £6 to £7 per acre would not be too much to deduct.

The condition and the growth of the trees are matters to be carefully taken into account. The distances at which the trees are planted is also of great importance. If too closely planted, so that they have to be thinned out, with the risk of loss and damage to the remaining trees, then allowance should be made on this account. That a rubber plantation should be a permanent investment must not be lost sight of. If too closely planted the estate must be thinned some time, and the sooner the better. For the cost of this allowance must be made. On an estate which has been too closely planted, the trees, even after thinning, can never have the same vigour and vitality as they would have if they had received fair treatment from the start.

The following statistics, issued in 1911 by the Klanang Produce Company, not only show the value of the returns from rubber, as compared with coconuts, " the consols of the East," but are of great assistance in arriving at the value per acre of a good, well-kept rubber plantation. The rubber trees in question were at the time from six to nine years of age.

RUBBER

Season	Total Crop in lbs.	Average Yield per Acre from Rubber over 6 years old	Cost of Production per lb., including Area in Partial Bearing	Average Price realised per lb.	Profit per lb.	Profit per Acre obtained from Rubber over 6 years old
		lbs.	s. d.	s. d.	s. d.	£ s. d.
1908	18,886	309.74	1 8	4 0	2 4	40 16 0
1909	39,729	630.88	1 3½	7 0½	5 9	181 7 6
1910	93,665	741.22	1 3	6 6¾	5 3¾	196 17 8

Cost of production would be lower but for the inclusion of areas in only partial bearing.

COCONUTS

Season	Total Crop in Tons	Average Yield per Acre from Clearings over 6 years old	Cost of Production per Ton	Price realised per Ton	Profit per Ton Net	Profit per Acre obtained from Trees over 6 years old
		cwt.	£ s. d.	£ s. d	£ s. d.	£ s. d.
1908	194.95	10.83	9 2 7	13 10 0	4 7 5	2 7 0
1909	181.11	10.06	8 3 4	17 6 1	9 2 9	4 11 1
1910	184.38	10.16	8 17 5	20 12 4	11 14 11	5 19 2

With rubber selling at a fairly high price it is evident from the above tables that £200 to £250 per acre for good rubber in bearing may not be too high a price to pay in the case of a well-kept, well-planted and well-cultivated estate.

When valuing a plantation it is seldom possible to have a proper survey of planted acreages taken at the time, or in time for valuation purposes. Some check on statements made, however rough, is eminently desirable. A pocket-compass is of great assistance at such a time.

When walking over the estate to be valued one should note in one's open notebook the hour and minute at which one starts from the boundary of the estate, or the beginning of the planted acreages, and the direction in which the compass points. Whenever a turn is made, the exact time and the exact direction of the needle of the compass should be noted. Walking easily over an estate at the rate of, say, 3 miles per hour, one can roughly measure the distance and make a diagram on a sheet of paper of the directions and distances, and so arrive approximately at the areas. The Chinaman cannot cheat one so easily, or so grievously, under such circumstances.

CHAPTER XLI

MEASURING DISTANCES

IN order roughly to measure distances, between trees for example, planters should learn to measure more exactly the distance they stride. A yard is a good long stride for most men. If one can depend on stepping exactly 2½ feet or 3 feet, it continually comes in useful on a plantation. It is also useful to be able to walk distances at a certain fixed rate of progression per mile and be able to depend on its being approximately correct. A square mile being 640 acres, or *vice-versa*, an area can be checked by walking steadily at a known rate of progression. Had some visiting agents been equipped with such knowledge it might have prevented 250 acres being reported on as approximately 600 acres. Such things have happened more than twice.

The following lengths multiplied by breadths equal an acre:

220	yards	long	by	22	yards wide
121	,,	,,		40	,,
110	,,	,,		44	,,
88	,,	,,		55	,,
69½	,,	,,		70	,,

There are 4840 square yards in 1 acre. Ten square chains equal 1 acre, and, as before stated, 640 acres equal 1 square mile.

APPENDIX

HINTS TO YOUNG PLANTERS

THERE are two native languages of special service to planters, Malay and Tamil. Malay is spoken all over the Malay Archipelago: in the Malayan Peninsula, in Sumatra, and more or less in Java. It is a simple, easily-learnt language, and if a universal language was really wanted, Malay would serve the purpose much better than Esperanto or Volapuk.

At least a slight acquaintance with the Malay language is useful if not essential before landing in the Straits Settlements, the Federated Malay States, Sumatra or Java. There are several good handbooks, but some of them are published in Singapore. *A Manual of the Malay Language,* by W. E. Maxwell, published by Kegan Paul, Trench, Trubner & Co., of London, is as useful as any and is easily obtainable.

Tamil is the language spoken by the natives recruited from Southern India. These natives form practically the entire labour force available in Ceylon apart from the casual labour of the easy-going Cingalese. In the Straits Settlements and the Federated Malay States the Tamils are a very large and increasing force, so that a knowledge of Tamil is only second in importance to one of Malay. *Ingē Vā,* published by Messrs A. M. & J. Ferguson, Colombo, Ceylon, is the best handbook obtainable on this language. This is no special commendation, for the book is by no means easily comprehensible.

HINTS REGARDING AN OUTFIT

1st. Bring as few European warm clothes as possible. They only mean extra weight and mildew. The same applies to leather boots. One or two pairs for occasional use are sufficient.

2nd. Having enough old, thin flannel suits for the voyage will save having to buy linen suits at an exorbitant rate in England when they can be bought in the East for from £5 per dozen suits. White or brown canvas boots or shoes can also be bought far more cheaply here than in Europe, the price being from 4s.

3rd. Tin air-tight trunks or strong uniform cases are best. Leather rots quickly.

4th. Thin cashmere singlets, or cotton, and socks are coolest and best.

5th. Evening clothes are seldom worn in Sumatra or Java, but a dinner-jacket is sometimes useful. In British possessions an evening suit is desirable.

6th. Linen and cutlery might be usefully bought.

7th. A strong 12 or 16-bore gun is of use sometimes in the evenings, but not so much as it used to be before so many clearings were made.

8th. A good, light, waterproof coat is necessary.

9th. Do not bring out medicines. Estates provide these and medical attendance free.

10th. If you have lists of the contents of your boxes you save trouble with the Customs.

HEALTH PRECAUTIONS

Always use mosquito nets and see that there are no holes in them. Make sure that there are no mosquitoes inside the curtains before blowing out your light.

Take a dose of quinine from time to time, especially in localities where there are cases of malaria at the time, or if badly bitten by mosquitoes at any time.

Do not drink water from wells or from streams which has not been boiled first.

Avoid chills. Do not sit in wet clothes. Do not sleep in a draught.

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