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Rubber – A Forest Product

By Anthony Thometz

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CHAPTER I.

INTRODUCTION

Rubber is one of the most important forest products used by mankind. The value of the rubber imported to this country is more than double the value of all other forest importations, including lumber, pulp, and dyewood. This discussion will be confined to one particular source of rubber, namely Hevea brasiliensis, because it furnishes 80% of the world's rubber supply. Although rubber is the product of the milky juice, or latex, which is found in the bark of a variety of trees, vines, and tropical shrubs, and is also found in much smaller quantities in the leaves, roots, and branches of other plants, Hevea owed its dominant position to its hardiness, adaptability, and to its continuous yield.

The history of rubber is of interest. The recorder of Columbus' second voyage to America describes the use of rubber balls made of latex from certain trees by the Haitians. Later voyagers tell us that the natives waterproofed their garments by dipping them in the latex juices. The process of collection and manufacture employed by these savages is described in an account published in the year 1615. This method, wherein the latex is smeared over the body of the collector, is still practiced in the most primitive tribes of the Amazon. About 1700 rubber was introduced to Europe where it was employed as an erasure and thereby received its name. In 1820 Macintosh developed a method of waterproofing garments with rubber. However these goods were very unsatisfactory since they stretched in summer and cracked in winter. Charles Goodyear, in 1844, accidentally dropped some rubber mixed with sulfur upon a hot stove and discovered the process of vulcanizing. This discovery was responsible for the wide use that rubber has attained, spreading from this simple beginning, until today, when we have over 30,000 separate articles made from rubber.

The source of supply until 1900 was entirely from wild rubber trees and plants, and wild rubber continued to furnish over one-half of the worlds production until 1912. As far back as 1834 the suggestion was made of cultivating the best kinds of rubber trees in the East and West Indies because even then it was difficult to secure the raw materials. In the 70's Sir Henry Wickham collected seeds of Hevea brasiliensis in Brazil and took them to London where they were germinated in the Kew Gardens. In August 1876 several thousand seedlings were shipped to Ceylon and set out. The demand for rubber caused by the growing popularity of bicycles led many to consider the practicability of producing rubber on plantations. In 1905 a boom market in rubber developed and the wildest speculations in rubber stocks ensued. The profits reported by the earlier planters were enormous, and these reports, coupled with the fact that the tea plantations of Ceylon were stricken with a severe fungous disease, led to large scale development of rubber plantations. All areas of the tropics were penetrated and today plantations of Hevea are found in most tropical regions, but the center of the trade is the Middle East, Ceylon, Malaya, Sumatra, Java, Borneo, and French Indo-China, where over 7,000,000 acres of rubber have been planted. 90% of the worlds rubber crop comes from this area, and only 3% is now obtained from wild trees. The growth of the rubber trade is strikingly revealed in these statistics of the U. S. Department of Commerce

WORLD RUBBER PRODUCTION

Year	Long Tons	Price Per Lb.
1910	10,916	$2.06
1920	305,520	.36
1930	800,000	.12

CHAPTER II.

THE TREE

There are 21 species of Hevea, a genus of the family Euphoribiaceae, but H. brasiliensis is the most important. It is a tall, handsome tree, often reaching a height of 100 feet, while the circumference may exceed 12 feet. A tree 280 years old is reported and it is thought by some that trees 400 years old can be found in the Virgin forests. The native home is Brazil where it is said to occur over an area of 1,000,000 square miles along the Amazon River and its tributaries. There is a wide variation in the stands of rubber trees but probably they comprise about 2% of the forest in the Amazonian jungles. Ordinarily there is but one to two trees per acre, but sometimes pure stands can be found. Hevea is generally found along river bottoms, and on clay lands subject to periodic flooding. The tree flourishes best on damp, rich soils where the temperature ranges from 89° to 94° F. at noon, and never falls below 73°F. at night.

Hevea brasiliensis never has a compact root systems, but has far spreading laterals and a well developed tap root. In plantations a radial spread of 20 to 30 feet in the first two years, in ordinary soil, is common and sometimes 2 yr. old trees will have developed roots more than 20 feet long. The planters employ this rule of thumb:

> "When Hevea is planted 15 feet apart, their roots will, in general, have met at the end of the fourth year."

The leaves are smooth with three spear shaped, pinnately veined leaflets 8 to 10 inches long. In Brazil the leaves fall from the tree about June at the beginning of the so-called dry season, and for a few days or weeks the trees winter with bare branches. The trees introduced in Ceylon have encountered there a reversal of seasons and leaf fall takes place in February. The flowers appear shortly after the new leaves. These are small, greenish, have a lime odor, and are borne in panicles. The male and female flowers are separate but are in the same panicle. The fruit ripens in about 5 to 6 months after pollination. Three seeds about the size of a chestnut, marbled with brown and gray are contained in a single fruit, which is a hard woody capsule. This bursts open when ripe and scatters the seeds for a considerable distance. Each seed is a slightly flattened ellipsoid and rather large at one end. One of the broad faces is usually rounded while the other is slightly flattened. Seeds germinate in about 10 days after dissemination. The fruit is oily and attempts have been made to use the oil commercially.

Commercially the most important feature is the bark which reaches a thickness of an inch or more in well developed trees. In examining the bark from the outside of the trunk, towards the pith, we find first of all a brown or gray layer of cork, which is generally thin in young and untapped trees, and which serves as a protective layer. Beneath the cork there occurs a thin dark green layer of living cells. Finally we have a granular yellowish or pinkish layer of tissue which makes up the greater part of the bark. Active latex vessels are distributed through this granular layer.

A word about latex vessels. Plants which yield latex are furnished with special sacs, tubes, or vessels, in which the latex is stored. In general these tubes form a connected system more or less longitudinally from the roots to the leaves. This system does not replace the ordinary tissues and the plant is quite complete without it. In Hevea the lactiferous vessels are formed from rows of special cells which are arranged longitudinally in the cortex. These cells are specially laid down by the cambium as latex cells and may be distinguished from the neighboring cells by their greater length and also by the cell contents. The cross walls that separate the cells are absorbed and continuous tubes are formed. Where two tubes adjoin, the lateral walls also become perforated and communication is established between cells. These cells are present in the embryo seedling and the process of absorption starts at germination. In the stem and roots these vessels are confined to the bark but continue upwards, accompanying the veins of the leaf to their ultimate end. Since the leaf system is continuous with the latex system of the stem, there is no reason to doubt that latex is being continuously formed in the leaf. As new tissues are constantly laid down by the cambium, the older vessels gradually loose their function and die. Eventually their remains are cut off by layers of cork and the rubber they contain is lost when the dry bark sloughs off. When the outer part of the living bark is removed in the process of paring, the young bark remaining is stimulated in a healthy tree to still more active growth. The time required by the bark for renewing such a thickness as will permit a repetition of the paring process varies. Factors which effect the rate of renewal are, the age of the tree, its relative size, state of nutrition, and site factors such as soil, elevation, and rainfall.

The fact that the latex vessels are entirely separate from the channels in which the food bearing sap is transported, gives rise to the question, what is the use of these latex vessels to the tree and what is the function of the milky emulsion which they contain? These are mooted points. It is certain that plants can get along without it and large quantities of latex have been removed without any visible injury to the health of the tree. The fact that the removal of latex stimulates the tree to produce large additional quantities of the substance, having nearly the same composition as the latex originally present, suggests that the formation of latex cannot be regarded merely as the excretion of a waste product. The removal of latex causes a sensible drain upon the supply of food available for general growth, accordingly it has been suggested that the latex vessels serve as conductive elements to supplement the phloem tubes, although the phloem is well developed otherwise. Other functions attributed are storage of food, water, excretory products, and finally as a protection against insect attack. None of these suggestions are tenable, although it is quite likely that the insect cementation theory is most correct.

Fresh latex as it flows from the tree consists of a fluid emulsion which closely resembles a rather thin cream in general appearance. The composition is also somewhat similar, except that the fats of the cream are replaced by a different hydrocarbon. This hydrocarbon has the emperical formula $C_{10}H_{16}$, which is the same as solid rubber. In the latex however the rubber probably exists in a liquid form. In this case the process of coagulation is either accompanied or followed by the solidification of the rubber globules. In freshly drawn Hevea latex the rubber globules are minute 1/1000 mm. in diameter. An analysis of Hevea latex shows that it is composed of the following:

H_2O	50-60%
Caouthchouc	30-45%
Resins	1-2%
Proteids	2-3%
Sugar	0.5%
Ash	0.25%

The latex from old trees usually contain a considerably larger portion of rubber than does that of young trees. The composition is not altered much by moderate tapping, but if excessive, the amount of rubber may be greatly reduced.

CHAPTER III.

WILD RUBBER

The tapper selects an area near the bank of a navigable stream and then searches out the rubber trees in this area. Perhaps 50 to 300 trees will be located and a trail is then built from tree to tree, after which the tapper is ready to start. The trees selected are generally 10-15 years old at least. The days work is begun at dawn, because in the early morning transpiration loss is slight and the latex will flow more readily due to the increased root pressure, and also because the high temperatures of mid afternnon coagulate the latex flow. A hatchet is used to wound the bark. The cuts are made in a slanting direction so that the latex flows from the upper end of the cut to the lower end. Three to twenty incisions are made at equal intervals around the tree, and cups are placed beneath them. These cups are made of tin plate and have a sharp edge which is inserted in the bark. The tapper continues on his beat until about 9:00 in the morning.

When the tapper judges that the flow of latex has ceased, he again returns over his morning route and collects the contents of the cups. The fresh latex is transferred from each cup to a 2 gallon tin pail and the cup is set aside until the following day when it is again placed under a fresh cut. The new cuts are made beneath the old ones, and on the average, at the end of 35 days the ground line is reached.

When all the latex is collected the tapper returns to his camp. A fire is built in a little pit over which has been built a cone of baked clay which has an opening at its apex.

The fruits of Attalea excelsa are widely used to produce a dense cloud of smoke that curls through the funnel described above. A pole about 6 feet long is laid across the smoking funnel. This pole is supported at each end by rails set on posts. About this pole the ball of rubber is formed.

A new ball is usually begun by allowing a little latex to stand in a pan overnight so that it undergoes natural coagulation. The coagulation, so formed, is rolled around the pole. Latex is poured into a pan set just back of the smoking cone. With one hand the operator rolls the ball over the basin, and with the other dips up the latex from the pan in a calabash, emptying this in turn over the ball. As soon as the latex ceases to drip the ball is rolled into the cloud of smoke, turned slowly so that the smoke covers the whole surface of the fresh latex and coagulates the rubber in a thin film. Then the ball is again rolled over the pan, coated with latex, and returned to the smoke. This process continues until the days collection has been made into rubber. The ball is then removed from the pole, rolled on a slab of wood in order to shape it and to squeeze out any liquid which remains. These balls weigh about 140 pounds.

Lumps of rubber which have formed in the latex of the cups, when in transit, or in the basin, are squeezed into an irregular mass, to which is added the film formed on the surfaces of the various utensils. Little attempt is made to keep this process clean and such rubber is inferior. In some localities the latex is smoked on a square paddle.

The method described is seen to be very wasteful. Great injury is done to the trees themselves. The tapper makes no special effort to avoid cutting the cambium. Frequently a chip of bark and wood is broken out, and as a result the base of old rubber trees resemble a pineapple because of the wound tissue(nodules) that develop. It is estimated that 10% of the latex is directly lost, and 75% of the yield is manufactured into a rubber of low quality.

CHAPTER IV.

CULTIVATED RUBBER

We have learned that Hevea brasiliensis has been extensively planted throughout the tropics and today these plantations are the worlds source of crude rubber. Let us consider the typical steps and practices employed on these plantations.

Hevea will grow at elevations up to 2500 feet, and even in rocky soils, if the area is in the moist tropics, that is within 10° of the equator. If it is properly protected from the wind it grows in comparatively dry situations, i.e., annual precipitation of 75 inches. It is on rich alluvial soils in the moist low country that the tree makes its most rapid growth and gives its earliest and heaviest yields. In selecting a plantation site rich jungles are cleared, which jungles must be handy to transportation facilities. When the land has been cleared a mixture of crops, rubber, tea, and tobacco will be planted.

In planting up a rubber estate nursery, plants 10-12 months old were usually employed. A suitable nursery was needed and in selecting the site the general considerations for nursery selection had to be weighed. At one time seedlings were raised in baskets and afterwards transplanted bodily to the planting site. These methods have become obsolete and the present practice consists of "budding" because of the advantages which accrue from the use of such stock. These were found by experience to be: 1. It is the best method of producing a uniform stand of uniformly high yielding trees.

2. Insect and fungous attack is not serious. 3. If a good union is secured no weakness results. 4. Bark renewal at maturity is satisfactory.

The principles of the "budding" method are quite simple. A rectangular panel of bark is removed from the stock at a point where no bud is normally situated. This panel is replaced by a correspondingly shaped patch containing a bud. The budwood is taken from a tree of high yield and healthy character. The panel is cut at a time when there is considerable growth activity in the stock. Ten to thirteen month-old seedlings are used for stock and when they have secured a good start on the planting site or in the nursery the budding operation is performed. The cut is made down to the wood and when the flap of bark is pulled back all the tissues external to the wood in--cluding the active cambium is removed. When the patch is placed in position the success of the operation depends upon two phases of activity proceeding rapidly, first, the formation of wound callus on the sides of the cut, and secondly, the development of a new cambium layer connecting the old cambium at the cut edges. When this union is completed the bud is in a position to begin active growth as soon as proper conditions are present.

The stock used generally is 13 months old but the amount of growth made by the seedlings is more important than their actual age. They should be about one inch in diameter at a height of four inches from the ground. There is actually no limit to the size or age of the stock but after the age of 2 years the operation becomes difficult owing to mechanical factors, such as the thickness of the bark.

The collection of budwood from a high yielding mother tree is an operation which is generally far from simple. The branches should have a thickness approximately equal to the stocks and their diameter should not exceed $1\frac{1}{2}$". The most suitable branches are the succulent leaders growing almost vertically in the upper part of the crown and therefore difficult of access. This difficulty can be overcome by pollarding the mother tree. In producing budwood on a commercial scale this method is too unreliable and does not furnish material in the large quantities needed. Use is then made of so called multiplication nurseries.

A multiplication nursery can be started from an ordinary nursery of seedlings, provided these are in regular rows at a regular distance, $1\frac{1}{2}$ feet from each other. All the seedlings are budded and when the buddings are 15 months old the first crop can be taken. When the stick of budwood is collected care must be taken not to cut this too low but to make this cut just above a place where a bud scar can be seen. In the second season growth will take place from these buds.

The instruments needed in the budding operations are few and consist of: 1, The "Parang" knife, which is about the size of a carving knife and is used to cut off the piece of wood from which the bud patch is stripped. 2, A pocket knife; this knife is used to make the incisions in the stock. 3, Budding wax, a special wax used to seal the edges of the wounds. 4. Budding cloth; this cloth is cheap unbleached material impregnated with molten wax and is cut in one inch strips about 20 inches long.

The process of budding is a one man job and requires a high degree of skill if a high percentage of success is to be obtained. The usual procedure takes this shape. The lower six inches of the stock is wiped clean with cotton waste. First a vertical cut 2½" long is made on the shade side of the stock to a distance of within one inch of the collar. The cut is made down to the wood, the feel of the knife announcing when this is reached. Then a parallel vertical cut, ¾ inch from the first, is made and the two joined at the top by a horizontal cut. When these cuts are made an outflow of latex occurs which should be allowed to run before the panel is opened. The budding cooly cuts 10-20 panels in advance, then returns and wipes off the latex with a rag.

A suitable bud is chosen and this is cut away with the larger knife, in a direction from the upper side of the bud, downward toward the base of the budwood stick. This cut should be started at least 1¼ inches above the bud and continued downwards for at least the distance above and below the scar. When this has been reached the bud attached to the chip of wood can be detached with a square cut across the bottom. The patch of bark is carefully loosened from the wood at the edges and then gradually peeled away. See figures 1. & 2.

The next sequence of events is carried out with an eye on the panel of the stock where the patch is to be placed. The sides are rapidly trimmed until the patch is about one-eighth of an inch less in width than the panel and when this is done the top is cut off straight to make the patch rectangular.

The patch when finished should be at least two inches in length. All this work is carried out rapidly with the bud patch shaded the whole of the time and without touching the delicate tissue which forms the lining of the inner side of the patch. The flap of bark covering the panel on the stock is stripped downward until a length of wood equal to the length of the patch is exposed. The two upper corners of the flap are pried up by means of the tongue of the budding knife and the upper edge is gently lifted. This edge is grasped between the thumb and the budding knife and the bark is pulled back until it can be seen that the bud patch will just fit the exposed panel. While this is being done the patch is held between the thumb and forefinger of the other hand and as soon as the flap has been pulled downward sufficiently it should be gently inserted in the panel. Care must be taken not to injure the cambium in any way. See Figure 2.

The flap is then loosely held in position over the bud-patch with one hand and a strip of cotton binding applied. The binding is continued spirally upwards with about a $\frac{1}{4}$ inch over--lap. The tension may be fairly strong at first but must be graduallyrelaxed so that little pressure comes on the middle of the bud patch. When the top of the panel is reached the tension is once more increased and a tight joint made with the concluding round turns. When the binding is finished, leaves are tied to the stock just above the budding so that it is protected from the direct rays of the sun.

The budding is left in this stage for 2 or 3 weeks and then the wrapping is removed. At this time the flap of bark, which originally covered the patch, is cut off and the shade leaves are renewed. The young bud will refuse to grow out as long as the dominating influence of the terminal shoot of the stock exists. Therefore to remove the influence of this shoot and make the new bud itself a terminal bud the stock is girdled a short distance above the new bud. This may be done one week after the binding is removed. If the budding is left to itself after ringing, it will be found that very shortly growth of the young bud will slacken and finally cease, while at the same time growth of the terminal shoot of the stock will begin again. To avoid this difficulty the stock is sawed off at the point of girdling, leaving a snag one-half foot long above the bud patch.

When the new shoot has reached some size it is lashed to the snag in order to prevent wind breakage. Four or five months later the snag is sawed off close to the union, plastered with a misture of cow dung and clay, and then the operation has been completed. For the next two years weekly inspections are made of the plantations and all side branches are pruned off up to a height of 8 feet above the ground.

The first plantations were closely spaced, 8'X8', but experience proved that stagnation occurred and much wider spacing had to be employed. Today 15'X15' is the absolute minimum, and spacings 20'X20' to 35'X35' are common. The young plants make rapid growth, 6 feet to 10 feet per year for four years after planting with an increase of 3 inches to 4 inches in girth per year. To secure maximum growth plantations receive intensive cultivation and both commercial and green fertilizers are freely applied.

CHAPTER V.

HARVESTING THE CROP

Preparations for tapping the trees are generally begun when the plantation has reached an age 4-5 years from planting. The age at which trees can first be tapped is determined by the thickness of the available bark. Experience shows that a girth of 18 inches 3 feet from the ground will sustain the effects of careful tapping, make satisfactory bark renewal and yield a certain amount of latex. Trees smaller than this give unsatisfactory yields and the cost of tapping and the risk of serious injury is high.

Tapping processes may be divided into methods of incision and methods of excision. In the excision or paring methods which are almost universally practiced, a thin shaving of bark is removed from the tree at each tapping. Incision methods are designed to extract the latex by pricking or gashing without removal of the bark. As far as the effect on the tree, paring methods are least harmful. In the herring bone system(paring) the uppermost cut intercepts the downward current of food over a certain area, and the remaining cuts, being vertically underneath it do not add to that effect; but in incision methods in which one-half dozen cuts are made around the tree, each cut has its effect and may amount to almost girdling. In this case too each cut ultimately produced a swollen knob which is an obstacle to future tapping. This knob resulted from a wounding of the cambium because the rotating pricker employed in the incision methods, when rolled over the bark, wounded quite deeply.

Methods of excision are universally employed and the patterns used are either one of these four: 1. The full herring bone. 2. The half herring bone. 3. The half spiral, and 4. The full spiral. See figure No. 3.

The actual process of tapping is as follows: The opening cuts are narrow grooves cut in the outer bark and extended to within about 1/8" of the cambium. The cut should be of equal depth throughout its length. Further tapping consists in removing a thin shaving from the lower side of the original groove on each occasion. In the best cutting the cuts are made to slope slightly inward so as to form a trough by which the latex can reach the conducting channel. The merits of good tapping consist in taking off the thinnest possible shavings compatible with the free flow of latex, and preserving an even depth of cut close to the cambium but never touching it. Although a wide variety of tapping tools are in use practically all are based on the principle of the gouge. Most cuts are made from right to left because right handed operators find it easier to make better cuts in this direction and more latex is secured. The angle of cut is between 30°-45°, 30° being used when the latex is thin, due to the saving in bark surface that results even if the flow is impeded.

The arbitrary distance between cuts is one foot and as a matter of convenience in tapping 6 feet is about the top height attained. In mature trees there is little difference between the initial yields of latex from areas of bark situated at heights of 1-3 feet above the ground and heights 4-6 feet above the ground. Generally speaking there is a slight falling off in yield as we pass up the trunk owing to the diminished thickness of the bark and the smaller girth of the tree. Many experiments have been made to discover what system of tapping produces the greatest yields. Results seem to indicate the following facts to be true.

Repeated tapping on a moderate system at intervals of 1-10 days leads to an immediate steady increase in the yield of latex obtained at each tapping. In the case of young and vigorous trees this increase may continue for an indefinite period subject to seasonal variation. The increase is found to take place even under daily tappings if the system adopted is such as to allow 4 years for bark renewal.

Under the comparitively uniform climatic conditions of Ceylon the yield of latex at certain seasons may be twice as great as at other seasons. The yield is greatest in wet weather and response to rain follows in 3 days. However the actual amount harvested in wet weather may show a decrease because the latex flows over the wet bark instead of along the cut and is therefore lost.

The yield from different trees of the same age and girth may vary 1000%. The percentage of rubber in the latex may also show this wide variation. The percentage of rubber is highest during the period of highest flow. Severe tapping leads to a marked falling off in the percentage of rubber present.

As a rule it is considered that alternate day tapping halves the labor charge and that it gives more rubber per tapping but that it does not give twice as much and therefore the total yield at the end of the year is less, the saving being made on the labor per pound of rubber obtained.

The rate of tapping should be reduced if:

1. The bark is being used at a greater rate than ¼ of the available amount annually.

2. The concentration of rubber in the latex falls below 30%.

3. The yield of latex fails to show an increase over the amount obtained at the corresponding period of the preceding season.

Average yields of rubber per acre, and per tree, per annum, as secured in Ceylon are:

Per Acre		Per Tree	
Age in yrs.	Amount, lbs.	Pounds	N.B.
4-5	50-100	Low 4	Some acres have yielded as much as 750 lbs per acre, per year.
5-6	100-150	Med. 5-9	
6-7	150-200	High 10-20	
8-9	200-250		
9-10	250-400		

CHAPTER VI.

"FROM THE TREE TO MARKET"

It is intended in this section to trace the actual steps and the technique employed in the conversion of latex to crude rubber as ordinarily done in the rubber plantations of the Far East.

I. Field Operations:

1. Tapping: Various systems of tapping are still in use, the principal of which at present are:- (a) The periodic system with daily tapping(V or spiral) on ½ the circumference of the tree. This system consists of periods of daily tapping for 4-6 weeks or longer, followed by similar periods of resting or cessation of tapping, (b) The V system on ½ the circumference of the tree on every alternate day.

2. Collection: A galvanized iron spout is fastened to the tree at the lower end of each cut. Beneath this spout a glass or porcelain cup is hung by means of cup hangers. The spout and cup hangers do away with the vertical channel formerly cut on the tree and materially increases the percentage of latex obtained. When 3-4 hours have elapsed since the time of tapping the cups are removed, swabbed out with the finger and the latex is transferred to an enameled iron pail. The cups, when not in use, should be inverted and hung on the tree. In this way water will not collect in the cup and the tendency of the latex to coagulate in the cup at the next tapping will be lessened. At the same time the cooly carefully removes the latex which has coagulated on the tree and in the cups and transfers this "scrape" to a separate bag. To the fresh latex an anti-coagulant is added,

generally sodium sulphite, although formalin and ammonia are often used. The latex is returned to a central point and is transported in tanks which may be drawn either by horses or by truck to the factory.

II. Factory Operation:

When the factory is reached the latex is weighed and the percentage of dry rubber is determined. The latex is then strained and a standardized rubber solution of 1½ lbs. of rubber to 1 gallon of latex is made up. This solution is then drawn off to the coagulating tanks and pans where acetic or formic acids(1 part of pure acid to 1100 parts of latex) are added to promote coagulation. These tanks are 10 feet long, 3 feet wide, and 1 foot deep and are so constructed that boards can be placed parallel to the ends throughout the entire length. When these boards are in place a series of partitions 1½" wide is provided, each of which will turn out a sheet of coagulated latex. Before these boards are placed into position the coagulant and the latex are thoroughly mixed. A piece of smooth wood which is nearly as wide as the tank, and in which one inch holes have been bored, is drawn up and down the length of the tank. During the stirring process much froth is developed, which if it is not removed, causes pitting of the sheet of coagulum. Consequently a smooth board is used to skim off this froth.

When coagulation is complete the sheets(3'X 1' X 1½") are removed and run through a series of rolling machines. In modern factory practice small power machines with rolls, 18"X 6" are used. The rolls of the machines should be set a suitable distance apart in order to produce a sheet of the desired thickness. The coagulum should be passed twice through the rolls with the rolls set widely, twice through a second roller with the rolls set closer, and once through a marking machine. Since the rapidity of drying is determined by the thickness of the sheet the 1½" blanket is rolled down to a sheet 1/8" thick. The output of a set of rollers is about 300 pounds per hour.

After machining, the wet sheets, which contain about 25% moisture, are hung in the open for 2 to 3 hours in order to drain. The final drying process is done in a smoke house. This is a rapid method and the absorption of creosote and other antiseptic substances from the smoke prevents or reduces the development of moulds on the sheets. Smoke houses are two-storied, the lower story containing the furnaces and the upper story contains a series of racks upon which the sheets are hung. The temperature is kept at 110°-120°F. and proper distribution of the fumes from the furnace is secured by ventilators, baffle boards and windows. At the end of the tenth day the sheets may be removed.

Three ply wooden veneer chests, 19" X 19" X 29" are used to pack the prepared sheets. Each chest will hold about 225# of smoked sheet. Before packing is commenced the chests are lined with overlapping pieces of sheet of the same grade as the centers, leaving sufficient length to overlap at the top after the case is filled. The rubber is then shipped to centers of world production where it is converted into the forms which industry demand.

In passing it may be said that a growing market for pure latex goods has created a demand for liquid latex. To meet this demand the new latex is mixed with ammonia gas (NH_3) and then shipped in 40-gallon drums or 4-gallon kerosene cans to other countries.

The costs of production in 1931 for a typical plantation in Malaya are illustrated graphically in figure 4.

CHAPTER VII.

A list of the more important diseases and pests and the recommended measures for control are as follows:

I. Fungus Diseases:

1. Leaf diseases

   a. Odium heveae: Fertilize in order to promote rapid recovery of the foliage so that satisfactory bark renewal, any yields, will be maintained.

2. Stem Diseases:

   a. Corticium salmonicolor - Pink disease:

   A thin pink film which overlies the bark is an indicator of this fungus. The pink patch spreads and ultimately covers the entire circumference of the tree. Under the central portions of the patch the cambium will die and the tree is eventually girdled. Control is based on keeping open stands so that the bark will dry rapidly after rains. Copper sulphate solutions, when applied to diseased parts, are effective in retarding the spread.

   b. Phytophthora faberi - Canker:

   This disease is responsible for a softening and rolling of the inner bark. Its presence is betrayed by a dark red secretion which oozes from infected portions. The only control is to cut away the diseased tissue and to rest the tree for some time.

3. Panel diseases:

   a. Ceratostomella fimbriatum - Mouldy Rot:

   Control measures are directed to thinning stands which will hasten drying out. Fungicides are also applied.

   b. Brown Bast--adopt less severe systems of tapping.

   c. Sun Scorch- -do not use black colored fungicides.

4. Root Diseases

a. White Root Rot - Fomes lignosus.
(most severe in young stands)

b. Red Root Rot - Ganoderma pseudoferreum
(most severe in old stands)

c. Brown Root Rot - Fomes noxius

d. Stinking Root Rot - Sphaerostilbe repens

Root diseases of the rubber tree are direct legacies of the original jungle stand. They are caused by fungal root parasites which propagate themselves by rhizomorphs. Under forest conditions these parasites become generally distributed and the sum total of their damage is not spectacular. But when the jungle is felled and burned the rhizomorphs no longer have living bark to enter and they are faced with extinction. If however a woody crop like rubber is planted the broken life cycle is repaired. Attack occurs in two stages: 1. In the first 4-5 years uniform infection occurs in the stand and manifests itself in the gradual infection and death of patches of trees. These patches of infection are equal in area to the original jungle infection. 2. When the roots of the new crop trees interlace the infection spreads to all trees in the plantation. The cleaner the area is the more quickly does the disease spread.

Control measures are directed to the complete removal and burning of infected trees, roots and stem, before the second state is reached.

II. Pests:

1. Animals: Elephants, deer, cattle, pigs and monkeys cause damage to plantations. Although some of these can be kept out by fencing, elephants and monkeys represent a difficult problem for which no adequate control has been found.

2. Insects: Under ordinary conditions a healthy tree is practically immune from boring insects owing to the presence of latex, which is an effective check to their progress. If on the other hand an area of bark is killed by fungus attack the latex soon dries up, and beetles contribute materially to damage done to the tree. Such attacks are purely secondary in importance.

There is one insect, Coptotermes curvignathus, prevalent in the Malay Peninsula which is able to cause considerable damage since it enters the living root. From the point of attack the spread is rapid and the interior of the root and stump may be hollowed out. Control methods are aimed at locating the nests and flooding these with the fumes of sulfur and white arsenic.

In nurseries insects play a more important role. Cutworms and grubs gnaw the roots of young seedlings. These may be controlled by applying a commercial insecticide "Kainit" to the soil.

Figure One

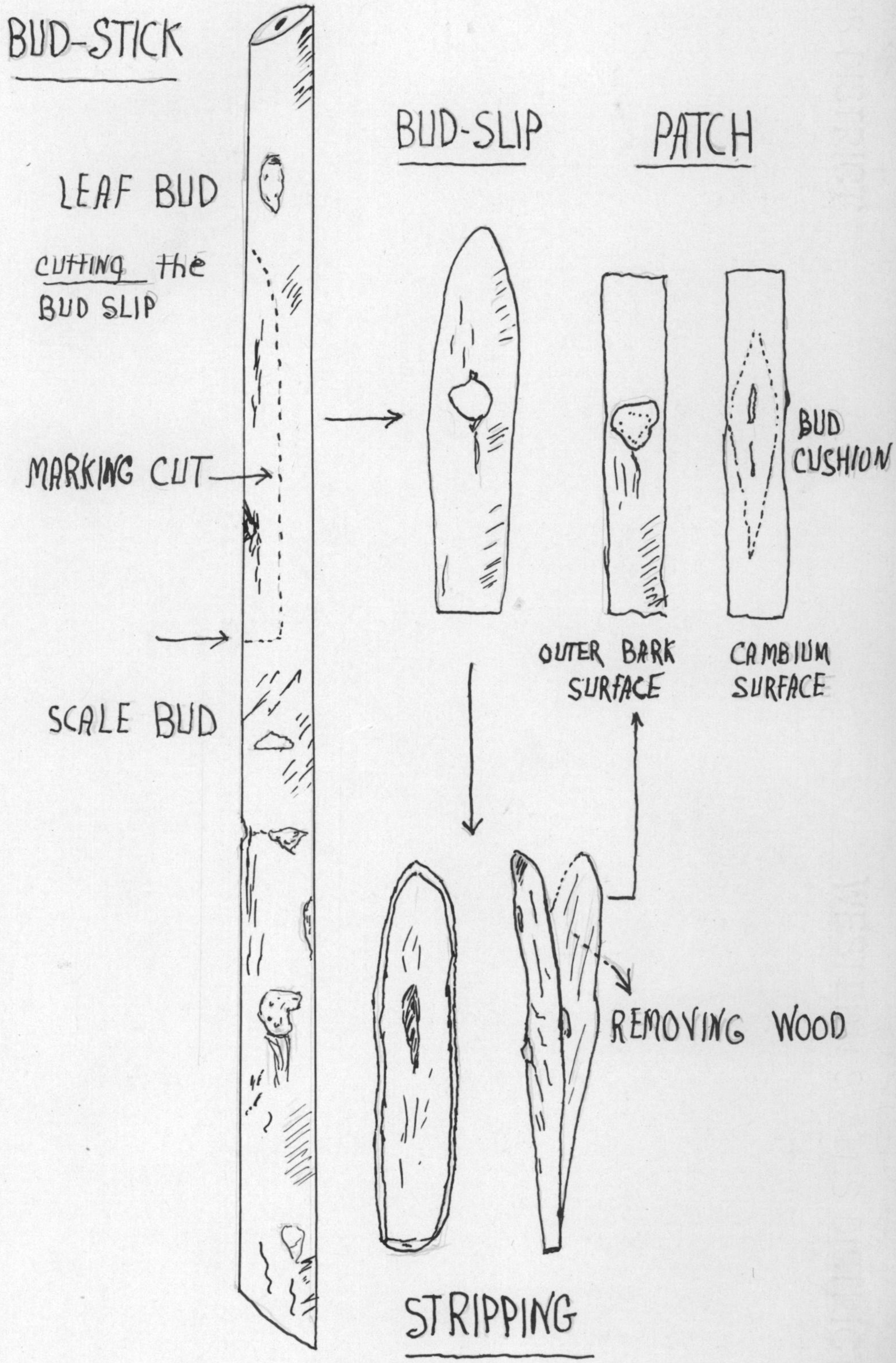
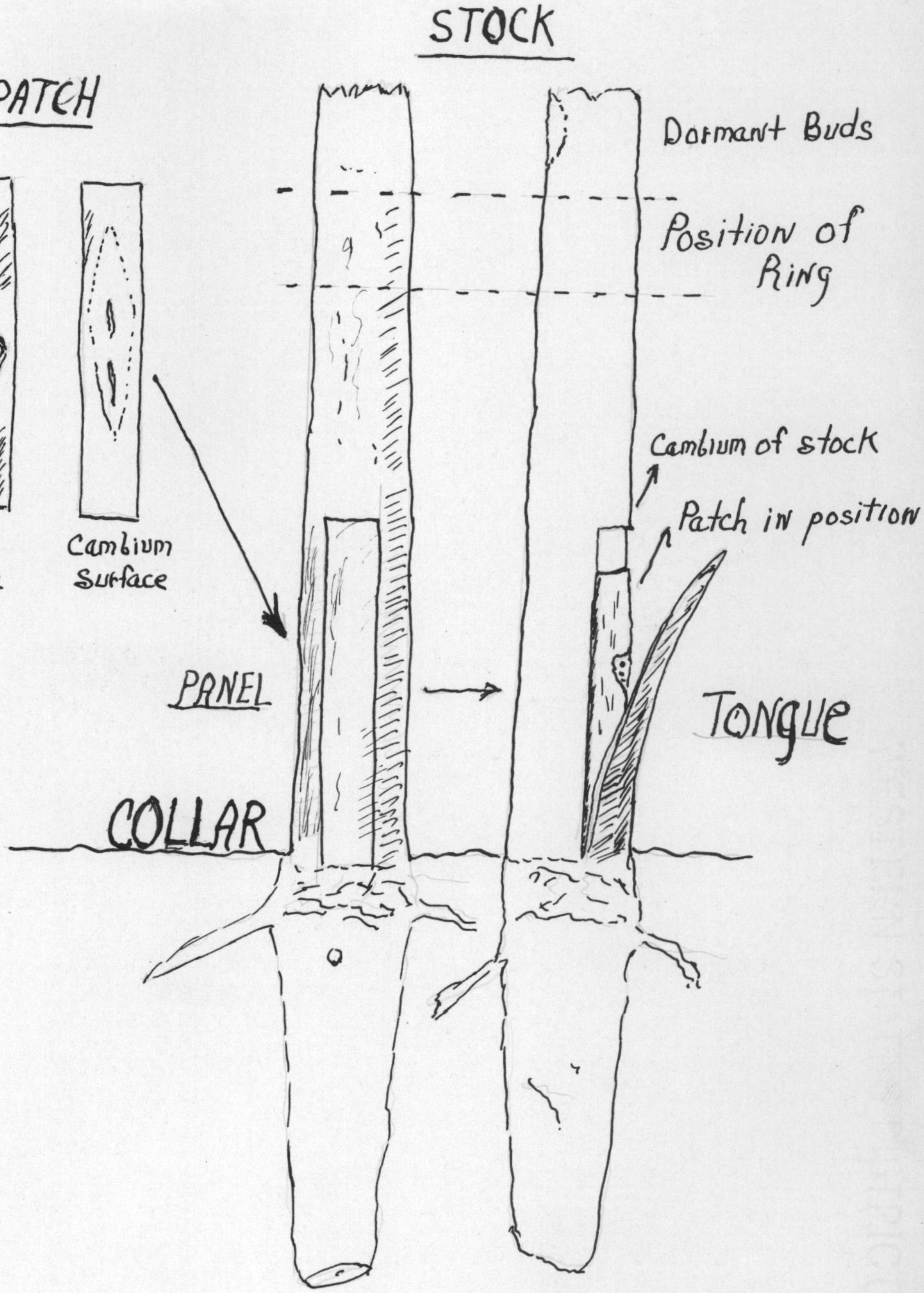
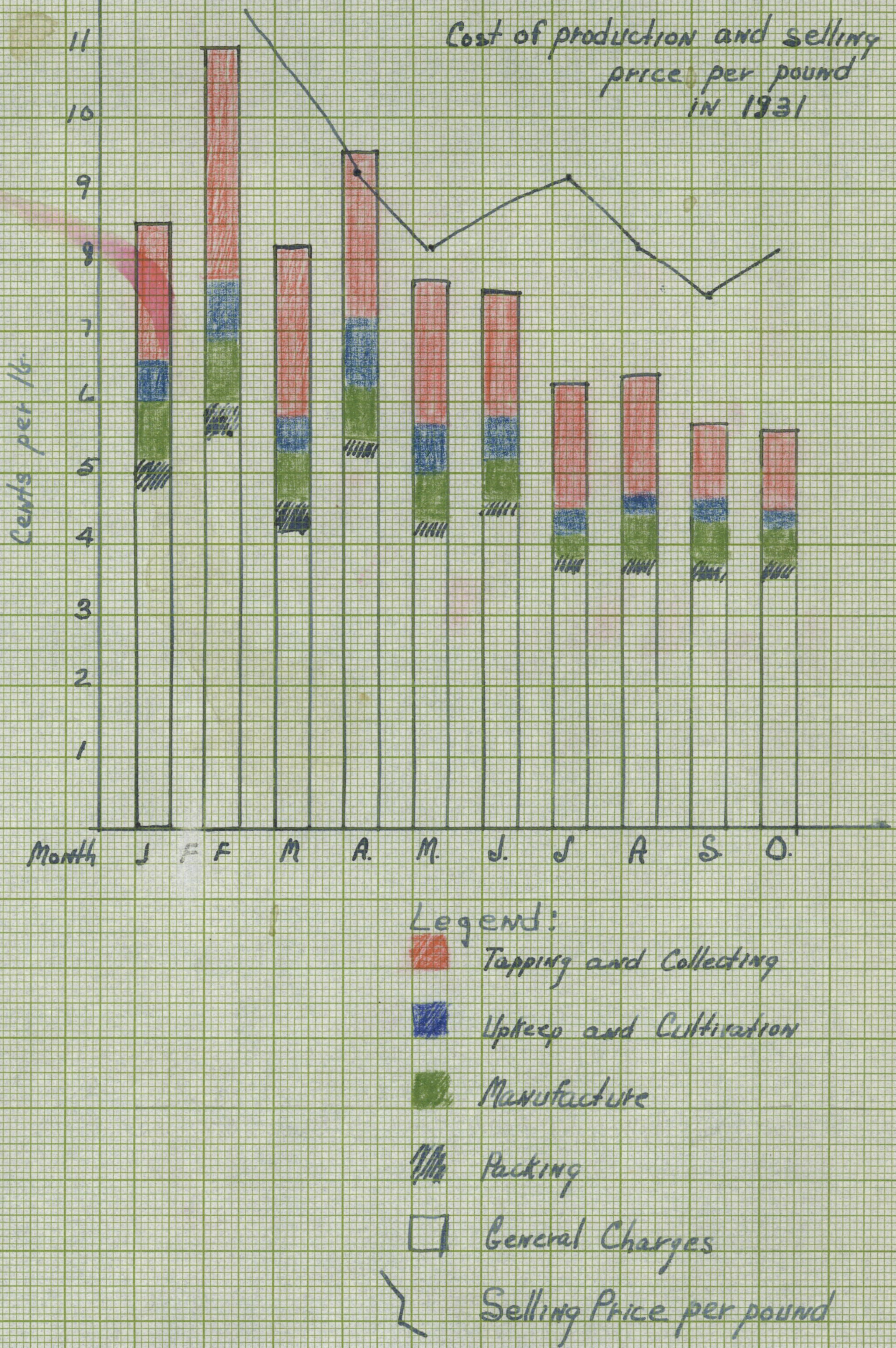

BUD-STICK
LEAF BUD
CUTTING the
BUD SLIP
MARKING CUT
SCALE BUD
BUD-SLIP
PATCH
BUD
CUSHION
OUTER BARK
SURFACE
CAMBIUM
SURFACE
REMOVING WOOD
STRIPPING

Figure Two



STOCK
PATCH
Dormant Buds
Position of Ring
Outer Bark Surface
Cambium Surface
Cambium of stock
Patch in position
PANEL
TONGUE
COLLAR

Figure Three



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