Germany and use for their own preferment and to the benefit of the home trade. The experience is considered justly a part of their education. In his latest novel, "Katherine Regina," Sir Walter Besant has a type of the young German clerk in London as one of his characters. He is more competent, reliable, industrious, and indispensable than his fellow clerks, and is content with a smaller salary—until he is ready to go home. With such insidious competition the Briton is finding it difficult to contend.

THE GREAT TEXTILE SCHOOL AT CREFELD.

As regards distinctively trade schools, these are more numerous in South Germany than in Prussia. A good example is the textile school at Crefeld, a town that is the Lowell and Manchester of Germany. Lowell opened a textile school just one year ago, while Manchester, England, has one under construction. The school at Crefeld was erected fifteen years ago at an original cost of \$200,000, and a \$60,000 additional building was put up a few years since. Besides the departments for spinning, weaving, dyeing, and finishing, there is a museum which is said to contain the finest collection of textile samples and patterns in the world, and designers from distant factories visit it daily for the purpose of draughting. As the result of an exhibition of Turkey carpet patterns at this school a factory for making Smyrna rugs has been started in the city, the first rival to the Bromleys, of England, in the production of this line of goods.

The library and reading rooms contain all the important textile books printed in every language. In the spacious quadrangle the large weaving room contains ninety different kinds of power looms run by electric motors, besides forty-four hand looms for the weaving of certain rare fabrics. The laboratories for the analysis of colors and for private research are extensive, and the dyeing school is as complete as the most modern dyehouse of a factory. The school is practically the center of inspiration for manufacturers of the district. The greater part of the silk trade of Germany, which amounts to over \$40,000,000 annually, comes to Crefeld, where, because of the school, it was found that in times of depression in the silk trade it was possible to initiate new textile industries to occupy the machinery and employ the workmen.

The dyeing department of this school is intrusted with the dyeing of the yarns used in the Royal Gobelins factories, of Berlin. Researches and experiments for outside parties are constantly being made by the students under the direction of the teachers, thus giving them a foretaste of the difficulties they will have to overcome when they enter commercial factories. Many of these investigations are made for local manufacturers who wish to reproduce the special tints of goods received from abroad. When a new loom comes into the market, it is immediately purchased. The teaching staff is twenty-two for five times as many pupils. At the Aix-la-Chapelle School, which is devoted to worsted and woolen spinning and weaving, the arrangements are equally elaborate; indeed, the school is, with some obvious limitations, a woolen factory, about sixty pieces of cloth being turned out each week. At Berlin there is a municipal higher weaving school for the education of managers, and here the sons of manufacturers are sent.

The "Gewerbe" or trade museums are important adjuncts to the school system. That at Nuremberg will give a good idea of their scope. There are eighteen different divisions, the first of which relates to applied art. There is a collection of patterns or samples which consists of 10,000 specimens of ancient and modern examples of work in wood, metal, glass, clay, leather, and paper, also woven fabrics, embroideries, and laces. In the second division are 60,000 sheets of illustrations of art industries of all nations and periods, classified and mounted under glasses in cases for easy reference. These may be copied. The library and reading room has 13,000 volumes of art, industrial and technical works, with 136 periodicals, foreign directories, trade catalogues and address books. All these rooms are open to the public.

INFORMATION ABOUT PATENTS.

The mechanical and technical division has departments for giving information on patents and trade marks, and patents may here be applied for and trade marks registered. Information is also given as to the machines, tools, raw products, and manufactured goods of all the world. Literary advice is given, course of study outlined, and technical questions answered. In the experimental department gas, benzene, and petroleum motors are arranged for trial tests, as are also steam engines, air compressors, water wheels, turbines, electric motors, and all labor-saving machinery. For these tests a fixed charge is made. The chemical laboratory occupies itself with investigations relative to technical and industrial chemistry and conducts researches.

We have nothing in this country that can be compared with the Gewerbe exhibitions that are given every few years in the large manufacturing towns. The one held in Stuttgart in 1896 is typical. It consisted of an artistic industrial section and an electro-technical section, the latter occupying the most space—for electricity and its application to the industries is receiving an enthusiastic reception in Germany. No less than 400 exhibitors took part in the electro-technical section, not only filling the Gewerbehalle and a temporary annex for machinery, but also occupying a specially constructed house in which every possible process connected with the domestic applications of electricity was shown in operation. A so-called "Gewerbedorf" or industrial village adjoined the main building, and comprised all kinds of small industries in which electricity was called into play, these applications being shown in action. The village had the appearance of a mediæval German town, and recalled the past industrial activity of Germany. It might have been old Nuremberg, to which Hans Sachs, the Reformation cobbler-poet, returned at the close of his wanderings, to his bench, his wife, his apprentices, his guild and meistersingers. One of the buildings was a fac-simile of the birthplace of Schiller at Marbach.

In this "Gewerbedorf" electricity was applied to cooking bread and candy making, type casting, and press work. Liquid carbonic acid gas was used as a motive power for beer engines and pumps. Electroplating, electrogravure, and photogravure were done, and there was a special chamber devoted to the Roent-

gen ray apparatus. The exhibition, at its close, was made the occasion of opening the new Landes Gewerbe as a permanent museum.

As regards the facilities for the education of the common artisan in Germany, evening schools are provided in every industrial village. Employers often arrange to give apprentices two afternoons a week to attend technical classes. The teaching is largely supplementary to shop practice, and care is taken to specialize the instruction in drawing to suit the trade followed. Pupils are compelled to remain in the public schools until fourteen, and are thus better prepared for receiving instruction than in places where primary education is not compulsory. Many have had four years in the secondary schools. As a direct result of this, the wages in all skilled industries in Germany are said to be rising; a certain degree of proficiency in school wins release from military service, and emigration is falling off. Child labor has practically disappeared. Everywhere in Germany there is evidence of activity, factories are going up, new processes are being invented, new schools erected. The people have the air of just having discovered that they are among the winners of the world's prizes, and are straining to reach the goal. The means by which they have been able to go so far in the race and overcome the obvious advantages of England are well worth considering.—Modern Machinery.

METHODS OF PREPARING RUBBER.

By R. H. BIFFEN.

So much has been written within the last few years on the subject of India rubber, the sources of our supply, and the possibility of acclimatizing the best yielding trees in our colonies, that at first sight it may appear that there is little more to be said. A study of the methods in use for preparing rubber from the latex, or milk, may, however, be of use to many interested in the formation of plantations, especially if some attention is paid at the same time to the inaccurate statements made in some recent publications, which apparently have disregarded the valuable series of papers on the subject contained in our one journal devoted to economic botany, "The Kew Bulletin."

The methods in use at present are either the outcome of the limited experience of uncivilized peoples or the application of experiments made without paying due attention to what is known of the chemical constitution and physical properties of latex. As a good example of the latter we may take the experiments of Morisse,¹ who found that coagulation was brought about in the latex of Hevea by the addition of alcohol, phenol, hydrochloric acid, nitric acid, sulphuric acid, calcium chloride, ferric chloride, corrosive sublimate, etc. As the outcome of these experiments, a mixture of phenol in alcoholic solution and dilute sulphuric acid was recommended as a coagulating agent.

The latex is, as a general rule, a thick, white fluid, composed of small particles of rubber in suspension in a clear watery solution of various substances. Unfortunately, only the latex of a few trees has, as yet, been chemically examined when fresh.

The analysis of the latex of Hevea brasiliensis shows that it contains:

Rubber.....	32	per cent.
Proteid matter.....	2.3	"
Calcium and sodium salts.....	9.7	"
Resin.....	traces.	
Water.....	55 to 56	"

It is slightly alkaline to litmus paper.²

The presence of albumen, globulin, and other proteids, has been demonstrated by Green³ in some other rubber-yielding latices.

As a general rule all these substances are to be found in rubber as it is at present prepared, often with others added to bring about coagulation of the latex, and accidentally or intentionally added impurities such as bark and clay. In all cases the percentage of impurities is large, how large we shall see later, and when it is remembered that some cause a rapid deterioration of the rubber, it is obviously much to the interest of those connected with the industry that a method of preparation should be adopted which would minimize them or insure their absence.

I propose now to consider a few of the better-known varieties of rubber.

Pará rubber is the product of Hevea brasiliensis, a tree which thrives in many parts of the Amazon valley, British Guiana, etc. As pointed out by Churchill⁴ in his consular report, there is no danger of this source of supply becoming exhausted, though this is the frequent cry of companies formed for rubber planting, usually fated for an ephemeral existence. The tapping is done with considerable care by the natives, and even should a district become exhausted, in a few years a fresh supply of trees springs up. From the planters' point of view, Brazil is hardly a suitable country, for the climate is bad, it is difficult to obtain labor, and the exchange is liable to endless variations. The trees have, however, been introduced into Ceylon, where small plantations exist, and into other colonies.⁵

The method of preparing the rubber has been so frequently described that repetition is needless; but a "translation of a valuable article on rubber of the Orinoco" has received so much attention of late that it requires some examination. One of its most striking errors is the following:

"As the juice contains a considerable quantity of water, the preparation of rubber consists essentially in separating the former from the latter, which is performed by evaporating the water by means of a heating process or obtaining its coagulation by certain chemical processes. Although the last system is more rapid, they prefer the former, as they pretend that the rubber thus obtained is of a superior quality—a supposition devoid of all reason."

As I have already had occasion to show,⁶ this statement is incorrect, for the heating continues for too short a time ("the rubber" is not "dried in a few minutes") to evaporate off some 50 per cent. of water, and further there is no loss of weight until the clot begins to contract and squeeze out water. Neither is "the supposition devoid of all reason," for it is a well known fact that the smoked rubber is far preferable to that obtained by chemical processes. A comparison of the prices of "Pará fine" and "sernamby" should be sufficient proof of this. Why it is so may be made clearer from the following experiment. At the end of a day's work I had several liters of latex left, to which an equal volume of water had been added, which would not keep overnight without coagulating. To this a small quantity of acetic acid was added, and in a short time the whole of it had formed a stiff curd. On pressing and drying, a portion of the water exuded from this mass of sernamby, but it still remained full of cavities, and the proteid matter in it quickly decomposed, so that ultimately a stinking, inflated mass was obtained.

If this latex had been coagulated by smoking, it would have yielded a wet rubber, but the subsequent decomposition of proteids would not have set in, for the creosote contained in the smoke would have acted as an antiseptic and prevented decomposition, as it does when meat is preserved by smoking.

Then again we find, "the rubber thus prepared (by smoking) acquires a darkish color, due to the particles of coal which adhere to the outer skin. Some people believe that this tends to improve it, but such is not the case, for it is thus impregnated with impurity."⁷ Now when these "bottles" of rubber are cut across, the fresh, laminated surfaces are a silvery gray color, and as each layer is exposed to the same extent to the action of the smoke, it is difficult to account for the outer layers only being so colored.

The freshly cut surfaces, however, soon darken and become black in turn, so that the explanation of oxidation seems far more probable, especially when taken in conjunction with the fact that the smoke is white⁸ and not black,⁹ for the nuts are simply dry-distilled and not actually burnt. If the smoke of these heated urucuri nuts is condensed, it forms two layers of liquid in the receiver, one a clear limpid solution consisting mainly of acetic acid, the other, darker in color, of creosote.

The hot vapor of acetic acid brings about the coagulation of the proteids of the latex, as may easily be proved by direct experiment.

A solution of alum is said to be in use for preparing rubber in some parts of the Amazon valley. Morisse¹⁰ states that alum solution has no effect upon the latex of Hevea species, however.

The loss in the factories on making up Pará rubber is as follows:⁶

1, Pará fine, 10 to 15 per cent.; 2, entre-fine, the carelessly smoked pieces, 15 to 20 per cent.; 3, sernamby, rubber pulled from the cuts on the tree and cups, coagulated by being allowed to stand, etc., 20 to 40 per cent.

From these data we may safely conclude that the smoking method of preparation is by far the best in use at present—a view which will be further strengthened when we compare the losses on making up other sorts of rubber.

Ceará rubber is the product of Manihot Glaziovii, a tree growing chiefly in the highlands of the state of Ceará, Brazil. Cross is responsible for most of the descriptions of the locality in which it grows, but as his experience of it appears to have been limited to Pacatuba, in which place its habitat is far from typical, they are not very accurate. He records it as growing at an elevation of 200 feet above sea level, among granite boulders, in a country whose dryness was indicated by the fact that "ferns, weeds, grasses, and mosses" were absent. True, it does grow among granite boulders, in the scantiest of soil in such localities, but it is more at home in the mountains, up to a height of 3,500 feet, and even more, where there is an abundant rainfall. These facts will serve to show the wide range of conditions the tree will put up with, and were it not for the smallness of its yield (1 to 3 lb. per annum), it would be invaluable for introducing into many of our colonies.

Coagulation is brought about either by smoking, as on the Amazons, or by simply allowing the latex to dry on the tree trunks or soil. The latter methods are objectionable, as the rubber invariably contains pieces of bark or grit. It may also be prepared by churning the latex, and pressing the resulting clots. The method is not to be recommended, though; for, even if the clots are cut into thin slices and exposed to the heavy pressure of a manioc press, a considerable percentage of water remains in its cavities, and decomposition sets in, but not to the same extent as in "Ceará scrap."

Although so impure it commands a price usually second only to "Pará fine." The loss is from 20 to 25 per cent., which, in inferior qualities, may even amount to 55 per cent.

Mangabeira rubber also comes from Ceará. It is the product of Hancornia speciosa, a dwarf tree with somewhat the habit of a birch. The rubber is prepared by the addition of an excess of salt to the latex, or by Strauss' method of adding alum. Even after thirty days' drying in the sun it is spongy and full of cavities of liquid. As might be expected, the loss on purification is enormous, amounting to from 40 to 60 per cent.

By this method of coagulating with chemical reagents it is impossible to get rid of the coagulated proteid matter, to say nothing of the greater part of the water. Morellet's¹¹ remark that "le procédé Strauss est ingénieux, mais les résultats de son application sont mauvais" may well be applied to all these chemical methods, and the sooner the search for coagulating agents is abandoned, the better.

The only other American rubber of importance, at present, is yielded by Castilloa elastica. It appears on

¹ Seeligman, Lamy, et Falconnet; "Le Caoutchouc et la Gutta-percha," Paris, 1896. P. 68.

² "Le Caoutchouc," etc., p. 94.

³ Green, "Proc. Roy. Soc." 1886, p. 28.

⁴ "Kew Bulletin," 1898, p. 241.

⁵ "Kew Bulletin," 1893, p. 159.

⁶ "Trinidad Bulletin," 1893, No. 18, and 1897, p. 36.

⁷ Biffen, "Ann. Bot." 1898, p. 165.

⁸ "Trinidad Bulletin," 1897, p. 38.

⁹ Compare the plate on page 757 of the "Jour. Soc. Arts," 1898.

¹⁰ "Trinidad Bulletin," 1897, p. 37.

¹¹ "Le Caoutchouc," etc., p. 67.

¹² "Le Caoutchouc," etc., p. 75.

¹³ "Le Caoutchouc," etc., p. 64.

the market in a number of different forms under the names of Mexican, Nicaraguan, etc. As far as we know, *C. elastica* is the only species of the genus yielding rubber, for the *C. Markhamia*, of Collins, turns out to be a *Perebea* species.¹

The latex is obtained in a rough and ready fashion by hacking a spiral channel from the crown of the tree to the ground, or by making great gashes with a machete.

Collins² has recommended a timber-scoring knife for tapping, and since then most writers have followed his lead. On experimenting with one, I found it was practically useless, as little latex exuded, possibly owing to the closure of the vessels by the drag of its edge. Stabbing with a broad-bladed knife, or with a chisel, as practiced in Ceylon,³ gives good results without much damage to the tree. In the previously mentioned article in "The Trinidad Bulletin" (1898) there is some slight confusion as to the localities suitable for the growth of *Castilloa*. In one place (p. 122), "it will scarcely thrive in regions that are not equally suited to *Hevea* spp," which (p. 130) grow "on land which is periodically inundated, even to a depth of five feet." Then (p. 121), "the tree (*Castilloa*) avoids marshy or boggy land, and manifests a preference for warm, deep loam, or sandy soil." The latter statement is the correct one.

The most general method of preparation in Mexico is to add an extract of the leaves and stem of the moon flower (*Ipomoea bona-nox*), and allow the mixture to stand overnight. The floating clot which forms is then pressed to remove some of the water.⁴ As in all these cases of preparation by "wet" methods the rubber contains large quantities of water, it loses from 12 to 30 per cent. on drying. Another method is in use in Nicaragua.⁵ The latex is mixed with about three parts of water, and allowed to stand overnight, when the rubber comes to the surface in particles, which do not unite to form a solid mass. The water is then drained off from below, and the rubber particles are mixed with a fresh supply of water, and the process is again repeated. The particles are then brought into a solid mass by pressure. The latest account of this method is apparently given by Hart, in an article on the "Coagulation of Rubber,"⁶ who appears to have rediscovered it. I quote it in full, as I may be mistaken:

"After the addition of water, the mixture is well shaken; the globules of rubber (having a lighter specific gravity than the albuminoids and proteids [sic] contained in the latex) will float quickly to the surface. It is found, moreover, that on the addition of further volumes of water and the removal of albuminoid liquors from below the floating rubber, the globules rise much more quickly to the surface."

The following criticism of this "creaming" process is given in "Le Caoutchouc et la Gutta Percha":

"Ce mode de préparation est bien rudimentaire et ne peut fournir qu'un produit de qualité inférieure, qui perd souvent plus de 50 per cent., surtout lorsqu'il fraîchement préparé."

Recently there has been some talk of extracting rubber from leaves and twigs by means of solvents, as has been done in the case of gutta percha. A description of this latter process may therefore be of interest. It originated in the smallness of the yield of the *Isonandra gutta* trees, a tree from twenty-five to thirty years old only giving 1.3 lb. of gutta percha when felled. The explanation of this fact is found in the work of De Bary,⁷ who showed that the laticiferous system of the tree consisted of short, closed sacs. This being the case, a great many would remain unopened, and thus a considerable percentage of the gutta percha would remain in the bark. As the demand for gutta percha has been large, and the supply has been obtained by felling the trees, they have become almost extinct.⁸

Serullas proposes to utilize the leaves and twigs of the shoots from the old butts to extract the gum from. They are dried, treated with caustic potash to destroy coloring matters, and treated with a solvent for gutta percha. The solvent is then distilled off and may be used again and again.

Rather more than 1 lb. of gutta percha is said to be yielded by 30 lb. of chopped up fresh leaves and twigs.¹⁰

For several reasons I do not think this process could profitably be applied to the preparation of rubber. The most important of these are, 1, on gathering the leaves and twigs there would be an immense loss of latex; and, 2, stripping trees of their foliage (the part which builds up their food supply) invariably kills them.

The direction in which research work should tend, I venture to think, is to prepare rubber free from the other constituents of latex, so that among other things, freight and customs charges on these impurities may be avoided.

Now it has been shown conclusively that the chemical constitution of latex varies with its source, so that it is improbable that any one reagent can be found capable of coagulating any given latex. Thus from the fact that acetic acid coagulates the latex of certain *Hevea* species, it cannot be argued that it will coagulate the latex of a *Kicksia* species.

Then expert opinions, as we have seen, show that the preparation of rubber by these chemical means is not satisfactory, for the product is far from pure.

I have recently succeeded, however, in preparing pure rubber by a physical process, and so demonstrated that chemical methods are not necessary. This is effected by centrifugalizing the latex in a special form of separating machine, when the rubber particles, which have a smaller specific gravity than the medium in which they are suspended, are thrown out of the bowl in an almost dry state. They may then be converted into a solid mass by slight pressure, or by

draining off the small quantity of water which remains with a porous tile. So prepared, the rubber forms a translucent mass, free from its usual smell and from all danger of decomposition.

The merits and demerits of this mode of preparation must rest entirely with me, but I cannot be responsible for any statements made in Trinidad, where a copy of my experimental machine was recently exhibited without my consent or knowledge.—Journal of the Society of Arts.

DEVELOPMENT OF NEGATIVES IN THE OPEN AIR.

OF all photographic operations, the development of the negative is the one that holds the most surprise in store for the operator. It is only at this moment that he knows whether the image is well defined, whether the light is harmonious, whether the time of exposure

FIG. 1.—THE ERNIE APPARATUS.

has been proper, and, finally, whether he has succeeded. So, when it is a question of a portrait in his studio or of a group in his garden, he takes care to do his developing at once in order to see whether it will be necessary to repeat his operations. But all this cannot be done in the country; and yet where it concerns a subject that the operator may not have an opportunity to meet with afterward, he may be glad to know whether his work has proved a success. At the time, now remote, in which gelatino-bromide was unknown and wet collodion employed, and it was necessary to do the developing immediately, M. Bourdin, a well known engineer, devised an apparatus that permitted of performing all the operations upon the spot and without a laboratory. Since gelatino-bromide plates have come into use there have been devised several apparatus that permit of developing and fixing without a laboratory, and not long ago we had an opportunity of examining a few new ones that deserve to be made known.

In the system devised by M. Ernie it is necessary, for the exposure of the plates in the camera, to have special frames that open at the bottom in order to allow the plate to pass into the developing apparatus. The latter consists of a square box (Fig. 1) surmounted at one of its corners by an inclined tube, *F*,

developer and of raising it from time to time, in inclining it in such a way that it shall be interposed between the eye placed at *F* and the red glass, so as to permit of watching the appearance of the image. When it is judged that the development is complete, the frame, *P*, is made to pivot and is so inclined as to cause the plate to slide into a frame, *M*, placed in front of an aperture arranged for this purpose and which is opened at the proper moment. This frame having afterward been removed and placed before another groove, the plate is allowed to slide into the tray, *S*, which contains hyposulphite. The trays are introduced through a special door that gives access to the interior of the apparatus.

All this is somewhat complicated, but, upon the whole, is capable of giving good results after a person has made himself familiar with the various manipulations.

MM. Cannier and Lafitte's device appears to us more

FIG. 2.—THE CANNIER & LAFITTE APPARATUS.

simple. It consists of a tight receptacle, *R*, transparent upon two sides, into which may be introduced and from which may be removed, in succession, the different liquids necessary, by means of two tubes, *A*, *B*, arranged at each extremity, and twisted spirally so as to arrest the light. The top of this receptacle is provided with a velvet-covered ledge for the reception of the frame, *A*, of the camera. This frame is provided with clamps, *T*, connected with a screw that may be maneuvered from the exterior in order to liberate the plate at the desired moment. After the frame has been placed upon the receptacle, *R* (which contains the developer), it is fastened down by means of the piece, *C*, which engages with bolts placed at the sides. Then the shutter of the frame is opened, and after the plate has been freed, the shutter, *V*, of red glass, is pulled out. The plate then falls into the receptacle, which is provided with supports in order to prevent the gelatine from touching the bottom. Finally, the red glass is put in place and the frame removed. The development is watched by transparency, and when it is judged sufficient, the bath is allowed to flow out by opening the cock of the tube, *B*. Pure water is made to circulate for an instant, then hyposulphite is poured in, and, finally, after the plate is fixed, it suffices to open the shutter, *V*, in order to remove the plate.

FIG. 3.—THE DONNY APPARATUS, CLOSED.

FIG. 4.—THE DONNY APPARATUS, OPEN.

to which one applies the eye in order to look into the interior. The opposite side carries a red glass which is covered or uncovered by means of a shutter, *H*, connected with the vision tube, *F*, by means of a chain. In the interior there is a metal frame, *P*, supported by two buttons, *U*, that are maneuvered from the outside. The slots in which these handles slide, without allowing the light to pass, permit of raising or lowering the frame and of inclining it in all directions. The tray, *R*, containing the developing bath is situated beneath.

At the upper part of the box there is a support in which is placed the frame, *A*, containing the plate that has just been exposed. A groove formed at this place allows the plate to pass when the slide that closes the frame is pulled. Care is taken beforehand to maneuver the buttons, *U*, in such a way as to bring the frame, *P*, vertically under this groove. The frame, therefore, receives the plate and permits of immersing it in the

All this is done somewhat rapidly, and the apparatus occupies but little space. Care must be taken, however, to arrange the frame of the apparatus in a special manner as regards the clamps that hold the plate.

The method of development devised by M. Paul Donny is very practical, because it is simple and applicable to all apparatus without any modification of the frames. In the cover of a box, *A* (seen open and closed in Figs. 3 and 4), are formed two apertures, *B* and *C*, provided with sleeves of black cloth into which one may insert his arms. The same cloth, thoroughly impervious to the light, forms a bellows and unites the cover and the box when the latter is open. In the center is fixed a red glass and in the upper edge of the cover is formed an aperture, *E*, provided with a shade for the eyes. In order to develop a plate, the box is opened, and through the door, *A*, are introduced the frames, the hand apparatus, the trays, and the solutions. Then the arms, having been in-

¹ "Kew Bulletin," 1887, p. 13, c. f. "Trinidad Bulletin," 1898, p. 21.

² Collins, "Report on Caoutchouc."

³ "Royal Botanical Gardens, Ceylon," 1898; Ser. I., No. 4, p. 30.

⁴ Belt, "Naturalist in Nicaragua," p. 33. Morris, "Colony of British Honduras," p. 76.

⁵ "Le Caoutchouc," etc., p. 62. "Kew Bulletin," 1887, xxviii., p. 16.

⁶ "Trinidad Bulletin," 1898, p. 131.

⁷ "Le Caoutchouc," etc., p. 62.

⁸ "Comp. Anat. Phan. and Ferns," p. 151.

⁹ Serullas, "Kew Bulletin," 1891, ccxiii., p. 230.

¹⁰ "Kew Bulletin," ccxiv., p. 231.