Revenue . Press.

G. No 408 of 1.4 1874

Read the following letters:—

No. 4. From J. BROUGHTON, Esq., Government Quinologist, to D. F. CARMICHAEL, Esq., Secretary to Government, Revenue Department, Fort St. George, dated Ootacamund, 1st December 1873.

I HAVE the honour to enclose a report on the manufacture of alkaloid from the Government Cinchona Plantations at Neddivuttum, and beg permission to be allowed to correct the proofs of the same before publication.

2. I further request that I may be allowed to have four copies of the same.

From J. BROUGHTON, Esq., B. Sc. Lond., F.C.S., Government Quinologist, to D. F. CARMICHAEL, Esq., Secretary to Government, Revenue Department, Fort St. George, dated Ootacamund, 1st December 1873.

I HAVE the honour in the following pages to make a report on the manufacture of alkaloid from the Cinchona bark of the Nilgiri Government Plantations, the reasons for my adoption of that form of febrifuge alkaloid, named by the late Inspector-General of Hospitals "Amorphous quinine," and the mode of preparation of that substance, together with the present results from the manufactory at Neddivuttum. In this report I will briefly recapitulate former statements and proceedings, in order that Government may have the matter fully before them.

Subject of Report.

2. My instructions from the Home Government, given in September 1866, with reference to this part of my duties, are as follow (Cinchona Return, 1870, page 4), "Finally, it will be expected from the Chemist that he should, through his investigations, enable Her Majesty's Government to arrive at a decision with respect to the best and cheapest method of preparing the febrifuge for use among the labouring classes of the natives of India. He will also be required to consider the question connected with the manufacture of the Cinchona febrifuge for the use of hospitals and troops in India."

My original instructions.

3. Two years after my arrival in this country I obtained, by experience, a knowledge of the advantages and defects of the Cinchona species cultivated on the plantations. That of which the largest number of plants was cultivated was the *C. Succirubra*. This species has by far the most vigorous growth and still forms the most considerable part of the plantations. Though, when young, its bark yields much quinine, experience shows that the amount of this alkaloid diminishes with age. The main alkaloids of this plant, however, are Cinchonidine and Cinchonine. In gross amount of alkaloid in its bark this species is surpassed by few others. I became convinced from the small amount of quinine this species yields, and the difficulty with which it is obtained in a pure form, that the red bark offered the least prospect of profitable demand by the European quinine manufac- turers. I have, therefore, done my best in all reports to check its cultivation, though in this respect I have been somewhat ineffectual, until too large a number had

Alkaloids of red bark mainly not quinine.

Scale of 1½ inch to a foot

been planted. My estimate of the final low market-value of this species is quite unchanged.

4. The reports of the Cinchona Commissioners in this and other Presidencies have, however, conclusively shown that the other Cinchona alkaloids possess a febrifuge power little, if at all, inferior to that of quinine. This conclusion, though it was fully expected on chemical and historical grounds, is of the highest importance. It was this that led me to the adoption of the bark of *C. Succirubra* as a satisfactory material for the preparation of a febrifuge which should be as effective as quinine sulphate.

Influence of reports of the Cinchona Commission.

5. The grounds on which I have long concluded that the febrifuge employed in the hands of Government for use in India can be more cheaply prepared in this country have already been communicated (my letter attached to G. O., No. 249, of the 7th February 1871). They are briefly these : The alkaloids are extracted with somewhat greater ease from the fresh, green bark than from dry. The necessity of drying, powdering, and the freight of the bark to Europe is saved. The supply being in the hands of Government allows a rougher and therefore cheaper mode of manufacture being adopted than is usual in Europe for the preparation of the alkaloid sulphates. Against these there are, of course, considerable difficulties to be expected in the carrying out of any systematic process worked by natives, from the lonely situation of the plantations of red bark and the annoyances that consequently arise in such an undertaking in a manner almost peculiar to this country.

Reasons for manufacturing alkaloids in India.

6. The actual Cinchona bases being, of course, the active medicinal constituents in the sulphates or other salts employed as febrifuge, it was necessarily believed that the bases themselves would be as effective medicines as these salts. The considerable amount of tinctures and extracts of Cinchona bark still employed in medicinal practice clearly show the efficacy of salts other than sulphates, nor, as far as I could learn, do the preparations made from Cinchona bark destitute of real quinine show any failure in febrifuge efficacy, a fact readily explained by the results of the Madras Cinchona Commission. Pure quinine sulphate contains but 73·55 per cent. of quinine. It was, therefore, believed that a preparation of the Cinchona alkaloids, in the proportion that they naturally exist in the barks, which would contain about ninety-seven per cent. of the pure bases, would admit of exactly the same medicinal doses being employed as of quinine sulphate. If there should be, for which there is no evidence, a somewhat inferior febrifuge quality in the alkaloids other than quinine, this would, it was believed, be compensated for by the larger amount of the real bases in the preparation in comparison with quinine sulphate. The report of the Medical Inspector-General, attached to G. O., No. 29, of the 11th January 1871, appears subsequently to corroborate these suppositions, as he states it to be "a remedy in malarious fever, scarcely, if at all, inferior to quinine." The evidence for the belief expressed by the Government of Madras in paragraph 3 of G. O., No. 714, of the 9th July 1873, I am unacquainted with.

Therapeutical considerations and results.

Proceedings of the Madras Government, Revenue Department,
1st April 1874.

7. Before describing the method of preparation I have adopted for the manufacture of the Cinchona alkaloids I believe it will be of service if I detail with brevity various modes of preparation which it was necessary to try and the objections that have arisen to each.

Methods of manufacture considered.

8. In a report appearing in Return on Cinchona Cultivation, 1870, page 243, paragraph 54, and more fully in a Memoir in Phil. Trans. Roy. Soc., 1870, I show that six-sevenths of the alkaloids in the bark of *C. Succirubra* occur in the form of quino-tannates. As this salt is nearly insoluble in water, the presence of a strong acid is necessary for its decomposition and complete solution of the alkaloid. It is this circumstance which constitutes the main difficulty in the preparation of alkaloid, since, even after the tannates have been decomposed in hot or dilute solutions, they partially re-form when the same solutions become cold or are increased in strength.

Alkaloids exist in bark as insoluble quino-tannates.

9. A method which has actually been employed in European manufactures, and which possesses great simplicity, is the percolation of the dried and powdered bark by cold dilute acid and the precipitation of the alkaloid by caustic soda. It will be perceived that this method either compels one to forego the advantage of obtaining the bark in its fresh, green state or renders a complete preliminary crushing necessary. I, however, carefully and repeatedly tried the method. The objections to it were that a large and expensive amount of acid was necessary for the nearly complete extraction of the alkaloid, which had subsequently to be neutralized with soda, and that on a manufacturing scale only two-thirds of the total amount of alkaloid was ever obtainable, and then not by any means in a pure state. The concentration of the bulky solution by evaporation increased the latter evil. In India the utmost possible economy in the use of acid is necessary.

Method of percolation with dilute acid.

10. I may here state that I prepared the crystallized sulphates of quinine and Cinchonidine from fresh red bark by digestion in the cold with dilute sulphuric acid and neutralization and evaporation of the extract. It was with great regret that after much trial I found it impossible to obtain more than a quarter of the total sulphates by this very simple method.

Crystallized sulphates of quinine and Cinchonidine can be obtained by the foregoing method modified.

11. A method of manufacture which, though I finally abandoned it, has the great advantage of not requiring the use of alcohol may be here briefly described. An extract is made by boiling the bark in the usual manner with four per cent. of sulphuric acid. When the bark is exhausted the extracts are evaporated to dryness and kept for half an hour at a temperature of 120° C. This completely decomposes the quino-tannic acid. The solid residue is powdered, exhausted with water filtered, and the alkaloid precipitated with caustic soda. It is thus obtained tolerably pure, though one-third of the amount is lost, and much of the alkaloid is converted into the non-crystallizable isomerides.

Method by heating the extract to 120° C.

12. The method of Clark and many others were also carefully and quantitatively tried, but the result led to their abandonment. Mineral oils, etc., were also experimented with to use in the place of alcohol, but without economical success.

Clark's and other methods.

13. The method of Delondre, which before I came to India had been tried by Mr. Markham (for the preparation of "quinium") was also fairly tried by me (Cinchona Return, 1866, page 218). It consists in mixing the powdered bark with calcic hydrate and water, drying and exhausting with alcohol. Nearly the whole of the alkaloid is thus obtained mixed with much resin and calcic salts, from which, however, it can be afterwards purified. The necessary preliminary fine division of the bark is a disadvantage of this process, but the most serious is the waste of alcohol which it entails, it being found very difficult to wash out the spirit from the spent bark as the latter swells up immediately water is applied. In extremely rich barks the method would be applicable, but with poor barks the great waste of spirit in proportion to the amount of alkaloid obtained renders the method quite unfit for the preparation of a cheap febrifuge. It consequently had to be abandoned, as I believe is now the case in the Havre Manufactory.

Delondre's method.

14. The method I have adopted is quite similar in principle to the usual method that since the time of Pelletier has prevailed in manufactories of Cinchona alkaloids. It consists in precipitating the alkaloids in an insoluble state and subsequently separating them from the mass of impurities with which they are mixed by solution in alcohol. The method is, however, so contrived that the very cheapest materials are used and the greatest economy is practicable with those materials which are not found on the plantations. The only material of which the consumption is large is that of wood fuel, which some years ago it was believed would be furnished in any amount by the Cinchona plantations by trees which had been coppiced. This, however, has not been the case, owing to the adoption of Mr. McIvor's system of mossing, respecting which I have already expressed an opinion which I need not further reiterate.

Principle of method in use.

15. The process was first tried in my small laboratory at Ootacamund, and I found that from eighty to niney-five per cent. of the total amount of alkaloid in the bark was obtained by it. If done with analytic precision, which, of course, cannot be practically carried out in a manufactory, 97·1 per cent. of that amount is obtainable, though I have never obtained this result when working with native coolies, but only when the work was performed by myself or by my Laboratory Assistant.

Experimental results of method.

16. The first product of this process, named by the late Principal Medical Inspector-General "Amorphous quinine," was prepared in the small experimental manufactory erected at Ootacamund, where enough was prepared from red bark grown at Neddivuttum for a fair trial of its medical efficacy. The results of its medical trial are contained in a report of the Principal Medical Inspector-

First trials of manufacture.

General attached to G. O., No. 29, of the 11th January 1871, which were considered highly favourable.

17. I will now describe the method of manufacture I have adopted, which though in the course of work has been constantly modified and improved, is, of course, susceptible of further improvements in detail.

Description of method now employed. Extraction of bark.

The bark in long strips, exactly as taken from the tree is placed in a copper pan with 1½ per cent. of sulphuric acid* and a quantity of water that has already been used for the fourth extraction of nearly spent bark boiled for an hour. The liquid and bark are then separated by strong pressure in a screw press, the former falling in a wooden vat placed underneath. The squeezed and nearly dry bark is again boiled with liquid that has been used for a third boiling of other bark and another half per cent. of acid is added. After an hour's boiling it is again squeezed. It is then again boiled with a liquid that has come off nearly spent bark, again squeezed, and finally boiled with water. During these four boilings the bark after each squeezing diminishes greatly in bulk and becomes almost pulp, so that it occupies far less room in a pan at the third boiling to what it did at the first. The order in which the several liquids used in extraction are employed depends on the qualities of bark under manufacture; but it is so arranged as to obtain finally a liquid containing as much alkaloid as possible in solution, and also that, as far as possible, the bark should be exhausted of alkaloid. Finally, there arrives a point when the amount of alkaloid in the bark has become so small as not to repay the expense of further extraction. The bark then is dried in the sun and used as fuel.

* This is the amount of acid employed for *trunk* bark, for *prunings* but one per cent. or even less is ordinarily used.

18. The liquid, which if the foregoing be judiciously managed should be intensely bitter and strong, is evaporated to about one-sixth of its bulk, transferred to a tub, and allowed to cool. It is then decomposed by neutralization with milk of lime which precipitates the alkaloids, decomposing the quino-tannates and sulphates with formation of insoluble lime salts. A slight excess of lime is always added. After standing for a day the precipitate is separated by filtration, squeezed, dried, and powdered in a common ragi mill. The liquid which contains abundance of calcic quinate in solution is thrown away.

Precipitation of extracts with lime.

19. As first conducted, the evaporation mentioned in the foregoing paragraph was omitted, the precipitation being at once performed in the original liquid. But, as alkaloid is unfortunately slightly soluble in lime-water, this proceeding was found to produce considerable waste, and therefore it was found necessary to evaporate in order to reduce this waste to a minimum. In India lime must necessarily be the precipitant as it is by far the cheapest of all the alkaline bases. I have tried both English caustic soda and Indian soudoo as precipitants of the alkaloid, but for many reasons do not now employ them.

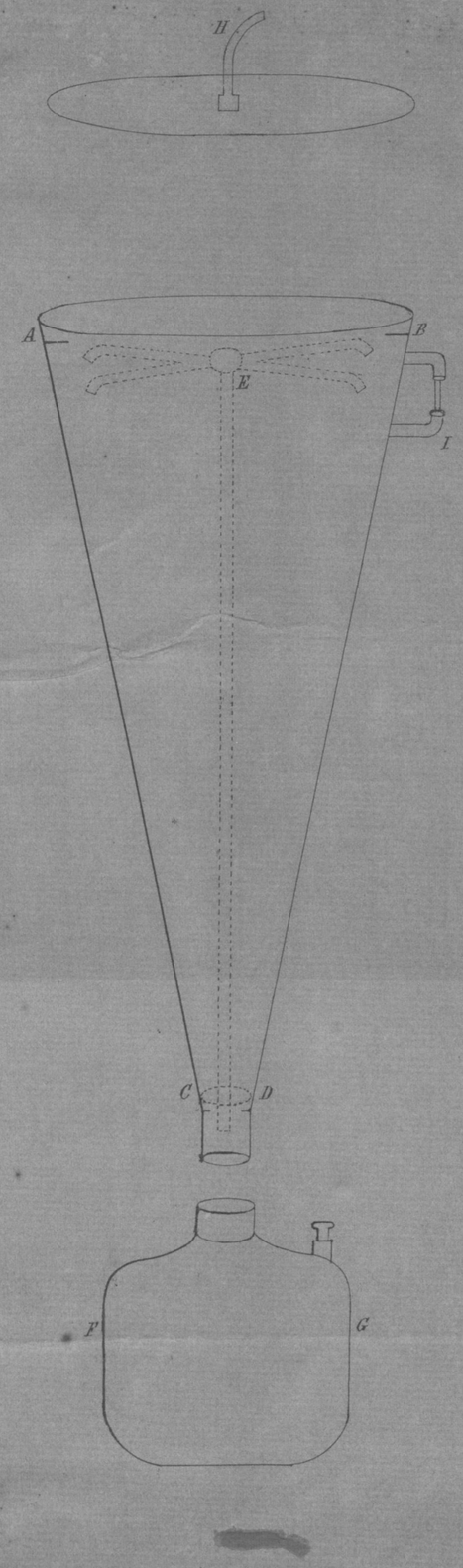
Evaporation was at first dispensed with. Necessity for the use of lime.

20. The powdered lime precipitate is then packed in the apparatus, of which a drawing is given, ABCD, being a large cone of sheet-iron, through the centre of which passes an upright tube the upper end of which terminates in a cross-piece with four openings. The lower end of the tube is also open and supplied on a flat perforated circular disk (CD) made of sheet-iron. This allows it to rest in the cone. Below, and tightly fitting to the lower part of the cone, is an under-copper vessel (FG). The cone is supported by chains and above, it is placed in connection with the lower end of a simple worm-tub (not shown in the drawing) by means of a tube (H). The powdered lime precipitate is filled in the cone till immediately under the cross tube (E). The upper lid of cone is fitted on and alcohol poured on till, by passing through the precipitate, the lower vessel becomes about a-third full. The spirit is then saturated with alkaloid, which is neutralized with care by diluted sulphuric acid of which the strength is known. Then the upper lid of the cone is put into connection with the upper condenser by the tube E and a fire is lighted below. The spirit boiling in FG rises in vapour through the inner tube and passes out at the four openings of the cross-piece. It here generally condenses to a liquid, but if not it passes into the copper condenser, where it, of course, condenses, so that by a judicious arrangement of the fire a layer of liquid is kept on the surface of the precipitate. A gauge (BI) allows this to be seen from the outside. If the fire is, however, kept too fierce no harm can ensue, since, if the layer of liquid rises in consequence higher than the percolation through the precipitate removes it, it simply passes down through the centre tube into the lower vessel. Hence the apparatus is self-acting and the cooly work-people have no connection with the alcohol, which is all inside the apparatus. A small amount of alcohol by constant circulation through the apparatus thus completely dissolves the whole of the Cinchona bases without any waste of spirit or alkaloid. Every two days the alkaloid is neutralized with dilute acid. If this be done with moderate care there is no chance of the copper under-vessel being in the least attacked, but if very carelessly done a mere trace of oxide of copper is dissolved. This, however, rarely occurs; but, if it does, it is readily remedied subsequently.

Proceedings employed to exhaust with alcohol.

21. The fire is thus kept up until the whole of the alkaloid is dissolved and passes into the lower vessel. This state of things is known by the alkalinity of the liquid in the lower vessel not increasing. But to make sure the spirit dropping from the cone is usually tested when the process draws near its end. When finished the exhausted precipitate does not contain a trace of alkaloid, all being in the lower vessel. The lower vessel is then removed and the alcohol separated by distillation. Water is also poured on the cone, in order to wash out the alcohol with which the precipitate is still moistened, until the latter is quite removed. The alcohol is thus nearly all recovered, and is purified for another operation by distillation. With care waste of spirit practically does not occur, but I have been unable yet to prevent all loss of spirit from the carelessness with which every operation in this country appears more or less attended. The loss however, has not exceeded six per cent., and has fallen frequently much below this.

Recovery and actual waste of alcohol.



Scale of 1½ inch to a foot

22. The alkaloid sulphates in the lower vessel is suddenly diluted with about ten times its bulk of cold water. This separates a considerable amount of black resin. Since the contamination of copper occurred in Bengal in the alkaloid I have always as a precaution added a small amount of a dilute acidulated solution of sodic sulphide to the liquid. This completely removes copper if it be present, though with very moderate care it is completely unnecessary. The solution is still, however, coloured with impurities, to remove which a small amount of alkaloid is precipitated by the addition of dilute caustic soda, which carries down with it the colouring matters. The whole is then filtered through a cloth bag, and the alkaloid in the filtrate is precipitated by caustic soda, separated by filtration, squeezed, dried, and powdered. It is then "Amorphous quinine." Before it leaves the manufactory as a precautionary measure it is always tested for copper.

Purification and precipitation of alkaloid.

23. Formerly, from the ashes of the fuel employed, caustic potash was prepared to use as precipitant instead of soda. But lately so small an amount of potash has occurred in the ashes that this has been discontinued. If the Cinchona wood from coppiced trees was employed as fuel this might be again resumed and thus a further saving effected.

Potash should be obtained from ashes of fuel.

24. Sulphuric acid has been used in preference to hydrochloric acid mainly because it is the cheaper acid. While the cost is nearly the same the effective work produced by the sulphuric acid is nearly double that of hydrochloric acid for equal weights. It has also some better qualities for transit through the tropics. The use of sulphuric acid has also some chemical advantages which I need not further particularize. With red bark there is unfortunately no fear of the sudden crystallization of quinine sulphate on the dilution mentioned in paragraph 22 as there would be with crown bark.

Why sulphuric acid is preferred for extraction of bark.

25. The alkaloid which is carried down in connection with the precipitated resin, and in the purification by fractional precipitation, is, of course, from time to time obtained free from impurities by the obvious methods of drying and digestion with dilute acids, etc. Thus obtained it is generally very pure and colourless.

Alkaloid contained in the resin is not wasted.

26. Throughout the whole course of manufacture simplicity of arrangement has been carried out as far as possible. The reasons for this are—

Simple apparatus throughout have been preferred.

1*st.*—That certain labour-saving appliances which are used in England would here be a source of considerable expense and are obtainable with great difficulty and delay. Until alkaloid manufacture in South India has proved itself a permanent success I have, therefore, felt it wiser to refrain from all dispensable expenditure for apparatus for which simple substitutes could be provided.

2*nd.*—That the simpler the apparatus the more readily are they repaired, when necessary, in India.

3*rd.*—The intelligence of Canarese coolies on the Nilgiris is fully exercised by the simplest proceedings of manufacture, therefore any increase in their apparent complexity has to be made with a risk of loss and injury to the apparatus.

27. The whole of the trunk bark supplied to the manufactory during the year 1872-73 has been obtained under the mossing system which has virtually been adopted by the Madras Government. This method of cropping bark has the disadvantage of only permitting the supply of good bark to be furnished during the two months at the beginning and the two months that end the monsoon. Hence during that time the pressure of work is very considerable while during the remainder of the year it is very light, so that I have been glad at the latter period to work with very inferior prunings, for the purpose of keeping the establishment employed, although I knew such bark could not be worked with profit.

Trunk bark is only supplied at beginning and end of monsoon.

28. Though I am aware the refraining from coppicing cannot be permanent, it has had a further result for which at the commencement of manufacture I was unprepared. At that time I believed the supply of fuel from the plantation would be unlimited from the coppicing of the trees. But up to the present time as coppicing has not been practically carried out no fuel has been obtained from the Cinchonas. The fuel hitherto employed has been furnished by the trunks and branches of trees that once formed part of the original Shola on whose site the plantations were formed, and now lie among the Cinchona trees. In a short time this source of fuel will be exhausted, and is now a more costly fuel than Cinchona-wood would be.

Plantations have not supplied fuel for manufactory.

29. I will now state the results that have been obtained in the year 1872-73 in the manufacture of Cinchona alkaloid and the actual cost of preparing the same.

30. I should state that a more recent examination of returns has shown that the 3,613 lbs. of *Officinalis* prunings mentioned in my annual report (paragraph 2, G. O., No. 714, of the 9th July 1873), had previously been included in the 46,440 lbs. stated as red bark prunings, and thus were mentioned twice over. The correction will, therefore, reduce the total amount of bark supplied to the manufactory by 3,613 lbs. I correct this for the sake of accuracy, though the difference to the amount of alkaloid due is but 4½ lbs.

A correction of the amount of bark supplied.

31. I have the honour to give in Appendix to this report a statement of the actual expenditure subsequent to last official year that has been necessary to work up the unfinished product of that year, which was in the state described in paragraph 18, or lime precipitate. The pay of the Superintendent is not included as during the time he has been mainly occupied in extracting fresh bark, and during the early part of 1872-73, he might have been similarly occupied in working up the lime precipitate of the previous working season had any remained. Every real expense has, however, been charged that has been required for the preparation of the alkaloid fit for sending to the Medical Stores, Madras. No repairs of apparatus have been required. All the resin, fractional precipitates, etc., have had the alkaloid separated in order to ascertain the true result of the work of 1872-73, so that nothing is assumed on estimate.

Superintendent's pay not charged in subsequent expenses.

32. From the lime precipitate obtained during the last official year that remained for exhaustion with alcohol 130 lbs. and 11 oz. of "Amorphous quinine" have been obtained. This is less than I at first expected and stated in my annual report. My estimate was founded on the amount of lime precipitate that required treatment, the yield of which was fairly assumed to be the same as that worked up in the year. I therefore hoped that a quantity of alkaloid not very far below the theoretical amount would be obtained. I now find that lime precipitate from poor prunings, like those worked up during the latter part of last year, contains far less alkaloid than that obtained from good bark. The extra expenditure necessary for obtaining this 130 lbs. and 11 oz. is, however, but small, being but 1 Anna and 8 Pies per ounce.

Amount of Amorphous quinine obtained from lime precipitate.

33. In order to determine the true total yield of the barks that were supplied in 1872-73 I have placed in Appendix the results of the many analyses that have constantly been made during the year. These have been performed, as far as possible, on a carefully selected average sample of each kind supplied. The results of this multiplied by the respective weights of the barks will express closely the total yield of the bark supplied. The total shows that 537·9 lbs. was contained in the whole of the bark. The total weight of alkaloid obtained in manufacture is 345·68 lbs.

Theoretical yield of total bark supplied.

34. It must not be supposed that it is possible in manufacture to obtain the same results as are obtained in analysis, as analytical methods of procedure cannot be carried out on a large scale, even if the cost permitted. Whether manufacturers, however, compared the theoretical yield of total alkaloids in the bark worked with the actual amounts they obtain in manufacture I do not know, but there is no record of their having done so. Quinine manufacturers are only specially interested in obtaining all the quinine from the bark, and would have no great care for the other alkaloids, which at the time I left Europe usually accumulated on their hands unsold. It is therefore, probable that a comparison such as I have made is made for the first time. It is on this account I have been anxious to have it as complete as possible, and hence the delay in the submission of this report.

Analytical results can never be obtained in manufacture.

35. I will indicate the sources of the loss of alkaloid which occur in the manufacture, nearly the whole of which are preventable only at a greatly increased cost of labour and product.

Sources of waste of alkaloid in manufacture.

1st.—The not quite complete exhaustion of the bark of alkaloid on first extraction with acidulated water. Usually the bark at the end of the boilings described in paragraph 16 of this report still contains a small amount of alkaloid which another boiling and squeezing would remove. This is not now performed, as the small amount of alkaloid obtained would not repay the cost of the labour, fuel, and subsequent evaporation.

2nd.—Spilling and waste of extract, and occasionally of bark itself, by the carelessness and indifference of the coolies. This is not preventable in India.

3*rd*.—Waste of material in grinding the lime precipitate and in final powdering of the alkaloid. This may, with care and training, be diminished, but cannot entirely be obviated.

4*th*.—The solubility to a small extent of the alkaloid in lime-water. At the beginning of the year 1872-73 loss from this source occurred. It has since, as I have before mentioned, been prevented by the evaporation of the liquid extract of bark down to a small bulk, before the precipitation with milk of lime is performed. I cannot fairly estimate the amount of waste that has occurred from this source but believe it will not have exceeded 20 lbs. of alkaloid.

36. As a measure of precaution I have repeatedly tested whether the lime precipitate is completely exhausted of alkaloid by the alcohol before throwing it away, and have always found that no alkaloid is wasted by imperfect exhaustion, as might otherwise be naturally supposed.

37. I will now state the total cost of manufacturing the alkaloid. In Appendix I give a statement of all the expenditure connected with the works for the working up of the bark supplied during the year 1872-73. This excludes the cost of apparatus and repairs, the latter expense being, however, but small. It also excludes my own pay, as manufacturing work can go on, after once established under the Superintendent, without the necessity of a Chemist's intervention. During the year my time has been more occupied with other duties than with the alkaloid works at Neddivuttum, which I visit but weekly.

Quinologist's pay excluded from manufactory expenses.

38. The total expenses, therefore, have been Rs. 2,823-11-9, and 345 lbs. and 11 oz. of Amorphous quinine have been obtained. This shows that the expense of preparing each ounce has been 8 Annas and 2 Pies. This does not, of course, include the cost of the bark, but is that of manufacture only. This cost is within my original estimate (letter attached to G. O., No. 249, of the 7th February 1871). This estimate was framed on the assumption that 800 lbs. were manufactured and that the bark worked had a mean yield of four per cent. of alkaloid when dry. The bark supplied in 1872-73 has had a mean percentage of scarcely three on account of the large quantity of nearly worthless bark from prunings, supplied during the dry weather, which frequently contained but 0·5 per cent. of alkaloid when dry. The results of manufacture on the score of cost appear, therefore, satisfactory.

Cost of manufacturing per ounce of alkaloid.

39. G. O., No. 714, of the 9th July 1873 does me the honour of requesting my matured opinion on the expediency of manufacturing any febrifuge in this country. Before expressing this I beg respectfully to make some remarks on paragraph 3 of the same Government Order.

Requests leave to discuss Government Order.

40. In this paragraph it is accurately stated that 1*s*. per pound may be taken as the value of (green) red bark, basing this estimate on the despatch from His Grace the Secretary of State, recorded in G. O., No. 1,429, of the 16th October 1872, in which it is stated that (commercially dry) red bark sold at from 2*s*. 1*d*. to 3*s*. 1*d*. per pound in England. This, of course, would be the value of the dried and packed bark after conveyance home. But if the manufactory be charged the

Value of bark attributed.

English price for bark grown on the spot in India, it will follow that the febrifuge must be produced at something near the English price of quinine sulphate, or, as the Government Order states, the cost of the alkaloid will be Rs. 3-9-6 per ounce. The present English price of quinine sulphate is 9*s*. 6*d*. per ounce, or roughly Rs. 4-12-0. If the Madras Government, therefore, desire the profit on the sale of Cinchona bark at the present English prices, it must not expect at the same time a febrifuge for Indian use at the price of Rupee 1 per ounce.

41. I will again state the reasons that to me appear convincing why the present English price of red bark cannot continue. This bark, whether renewed under moss or not, is nearly unfitted for the manufacture of quinine as it contains so little, and that little is difficult to obtain as crystallized sulphate. It is used for the manufacture of tincture and other pharmaceutical preparations. I am informed on good authority that annually 1,00,000 lbs. of Cinchona bark are used for these purposes in England. Without counting the Government plantations the private plantations of the Nilgiris contain nearly a million and a half of trees of *C. Succirubra*, which will in a short time supply at least fifteen times that amount annually. To this must be added the yield of the private plantations in Bengal and in other parts of the world. I cannot but conclude that with this enormous supply the price of red bark must very shortly fall in the English market till it only just pays for the cultivation and export. It is quite possible that the employment of Cinchonidine and Cinchonine in medicine may hereafter give red bark a certain manufacturer's value, but much time must elapse first. At the present time the qualities of Indian red bark are scarcely known in England, but they will shortly become so. The foregoing are, therefore, the reasons, as I before stated, on which my choice of the form of febrifuge and the bark from which it is to be obtained are mainly founded.

Reasons why the price of red bark will decline.

42. But for a short time to come the value of the bark attributed to it by Government will doubtless be the main influence in their estimates of the expediency of manufacture in South India. In all papers previous to G. O., No. 714, of the 9th July, it appears to be implied that the actual cost price of the bark on the plantations should be the element of cost in that of the alkaloid. If the present prices obtained by the sale of bark in England be debited to the alkaloid manufactory for its raw material, it is quite clear that a cheap febrifuge will be impossible, and I could have positively stated this before coming to India. The profits of sale and cheapness of febrifuge cannot co-exist. If all the bark whose alkaloids will finally be used in India be exported, the additional and apparently unnecessary labour of drying, packing, transport, and sale of bark will be taken, and the advantage of the control of manufacture will be sacrificed which permits a more abundantly occurring form of febrifuge to be used in India. It is for His Excellency the Governor in Council to determine whether the profit of sale of red bark in England or cheapness of febrifuge for use in India be the end to be obtained.

English prices of bark incompatible with cheapness of febrifuge.

43. My matured opinion, therefore, does not differ from the one I formerly expressed concerning alkaloid manufacture in India (letter recorded in G. O.,

Manufacture to some extent must continue.

No. 219, of the 7th February 1871). But, under any circumstances, as long as Government export red bark, advantage will be found in having some means of obtaining the alkaloid contained in the bark of prunings and waste bark that is not worth carriage to England, which must always occur on the plantations in considerable quantities. Therefore, if my opinion is not held by Government, the small manufactory now established in action will still have work.

44. I would suggest that, if any doubt is felt of the medicinal efficacy of Amorphous quinine after the original report of the Inspector-General of Hospitals, recorded in G. O., No. 29, of the 11th January 1871, that a further expression of the opinion of the Medical authorities on the same should be called for by Government.

Suggests further medical report on Amorphous quinine.

APPENDIX.

Cost of Alkaloid manufacture from the Cinchona Bark supplied during the year 1872-73.

Description of Charges.	Cost. Rs.	A.	P.
In year 1872-73.			
Pay of Superintendent and Coolies ...	1,744	8	0
Extra labour	62	15	6
Contingent expenses	102	11	6
Fuel	82	0	0
Lime	72	8	0
Carriage of Alcohol and Lime	33	10	9
Cost of Alcohol used	90	0	0
,, of Acid sent out by India Office ...	407	0	0
,, of Soda	19	13	10
Subsequent Expenses.			
Cost of collecting Fuel	37	3	0
Labour	56	8	6
Soda	9	13	6
Alcohol	84	0	8
Acid	6	5	0
Oil	11	9	4
Cost of powdering the Alkaloid	3	0	0
Total ...	2,823	11	9

	Bark sent green as analyzed.	Per cent. Dry.	Weight of Dry Bark.	Per cent. of Alkaloid.	Weight of Alkaloid.
Bark of *C. Succirubra.*					
1st April to 20th May 1872.					
Neddivuttum, Trunk	943	30	282	4·1	15·5
Do. Prunings	10	.....	.....	.....	.....
20th May to 18th June.					
Neddivuttum, Trunk	2,118	28	612	7·1	43·4
18th June to 3rd July.					
Neddivuttum, Trunk	3,140	29	910	.....	38·2
3rd July to 18th July.					
Neddivuttum, Trunk	2,184	29	633	5·1	32·2

	Bark sent green as analized.	Per cent. Dry.	Weight of Dry Bark.	Per cent. of Alkaloid.	Weight of Alkaloid.
Bark of *C. Succirubra.*					
18th July to 7th October.					
Neddivuttum, Trunk*	7,767	30	2,330	4·8	111·8
7th October to 16th October.					
Neddivuttum, Trunk	7,357	26·8	1,971	4·3	84·7
Do. Prunings	814	25	203	1·7	3·4
16th October to 24th October.					
Neddivuttum, Trunk	2,679	25·8	691	3·5	24·1
Do. Prunings	533	25	133	2·6	3·4
24th October to 4th November.					
Neddivuttum, Trunk	3,860	27·7	1,071	4·3	46·0
Do. Prunings	4,749	24	1,139	2·6	29·6
Pykara, Trunk	958	27	258	5·0	12·9
Do. Prunings	1,480	25	370	1·6	5·9
4th November to 21st November.					
2 Neddivuttum, Trunk	24	28	6	5·0	0·3
Pykara, do.	750	27	202	5·2	10·5
Do. Prunings	1,486	25	317	1·5	5·5
21st November to 13th December.					
Neddivuttum, Trunk	22	27	6	4·0	0·2
Do. Prunings	66	25	16	2·2	3·5
Pykara, Trunk	1,419	27	383	4·0	15·3
Do. Prunings	4,875	25	1,219	1·1	13·4
13th December to 9th January 1873.					
Neddivuttum, Prunings	1,251	25	312	1·8	5·6
Pykara, do.	7,100	24	1,700	0·5	8·5
9th January to 10th January 1873.					
Neddivuttum, Prunings	135	25	148	0·7	1·0
Pykara, do.	450				
10th January to 27th January.					
Neddivuttum, Prunings	1,671	24	1,636	0·5	8·1
Pykara, do.	5,147				
27th January to 24th February.					
Neddivuttum, Prunings	†7,603	25	1,900	0·6	11·4
Pykara, do.					
24th February to 3rd March.					
Pykara, Prunings	1,890	25	472	0·5	2·3
3rd March to 18th March.					
Neddivettum, Prunings	1,147	Not worked.			
Pykara, do.	2,520				
Prunings of *C. Calisaya*	450	27	121	1·0	1·2
Do. of *C. officinalis*	3,613	Nearly worthless.			
Total...	80,281	.....	19,041	79·5	537·9

* 600 lbs. from decayed trees.

† 3,613 lbs. of prunings of *C. officinalis* have here been deducted.

No. 5. From J. BROUGHTON, Esq., B.S.L.F.C.S., Government Quinologist, Ootacamund, to C. G. MASTER, Esq., Acting Secretary to Government, Revenue Department, Fort St. George, dated 14th March 1874.

I HAVE the honour, as directed in G. O., No. 286, of 2nd March 1874, to submit a statement of the total expenditure connected with the Alkaloid Manufactory, the quantity of bark consumed, and the outturn of "Amorphous quinine" since the year 1869.

2. In a report of December last, I had the honour to detail the full cost connected with the manufactory during the year 1872-73 and extending to the time that the manufacture of the bark supplied during that year was completed. I also, in that report, entered fully into the various reasons which induced me to adopt the form of febrifuge I have since prepared, and the various hindrances and advantages connected with manufacture in India. Of the hindrances the most important is a purely artificial one, which is due to the Commissioner of the Nilgiris and the Superintendent of the Plantations, and not to the merits of its cause, I allude to the "mossing process," which has limited the supply of good bark to the manufactory to but four months of the year. As the objections to this method of cropping will shortly speak for themselves, I need not further discuss them.

3. The figures I have now the honour to submit are, therefore, those more connected with a time when the manufacture was mainly experimental. This is specially the case with the details of the Ootacamund manufactory. They should not, therefore, be taken as those of a constant and current manufacture. The adaptation of a manufacture of a new substance to meet a special want to the conditions of an Asiatic country necessarily renders tentative work unavoidable. A constant and regular supply of bark to the manufacture, such as might be easily rendered, would yet diminish the current cost of "Amorphous quinine" to a lower figure than I have hitherto been able to reduce it. For a fuller discussion of the conditions of working and value of bark, etc., I must, however, refer to my report of December last. The bark has been almost exclusively that of *C. Succirubra*, much of which has been prunings of but small value, the weights are those of the green bark. The market-value of a substance like "Amorphous quinine," which is in a form quite unused in European medicine, must depend on its intrinsic value. From the report of the Medical Inspector-General, it appears to have perhaps the same febrifuge effect as quinine sulphate.

4. I fully coincide in the views stated by Mr. Howard in his letter accompanying G. O., No. 286, of 2nd March, with respect to the advisability of by degrees substituting cinchonidine sulphate for the quinine sulphate. This will have the ultimate effect of raising the value of *C. Succirubra* bark, which otherwise will, from its large production, fall very low. I have stated this fully in my report of December 1873. From information I have gathered from Medical officers in this country, I am convinced that there is no risk of efficiency, but in some respects positive gain in the cautious substitution recommended by that gentleman.

5. Mr. Howard also recommends that the *C. Succirubra* cultivation should partially be changed for that of *C. Calisaya*. I had the honour to recommend the same in my report of August 1873, attached to G. O., No. 208, of 15th December 1873, and remain entirely of the same opinion I then expressed. As the matter has been referred to the Commissioner of the Nilgiris for the opinion of the Superintendent of the plantations, I am glad to have my recommendation corroborated by that of Mr. Howard.

6. The details I now submit are rendered briefer by the circumstance that I am preparing to leave India on the six months' leave granted in G. O., No. 102, of 23rd January, and have already commenced my preparatory leave from the 4th instant. The details, however, appear to contain all those requested by Government, and a full discussion of the question was submitted in December last.

Proceedings of the Madras Government, Revenue Department,
1st April 1874.

Statement showing Expenditure incurred on the Alkaloid Manufactory during the official years 1869—1873, inclusive.

Description of Charges.	Cost.			Total		
At Ootacamund, 1869, 1870, 1871.	Rs.	A.	P.			
Buildings	7,309	4	6			
Apparatus	750	12	11			
Water-supply	400	0	0			
Alteration of Press	160	0	0			
Alcohol	174	12	11			
Soda	20	0	0			
Acid	47	12	0			
Fuel	304	13	1			
Sanctioned establishment	2,108	5	7			
Contingent expenditure	459	3	2			
				11,735	0	2
At Neddivuttum, 1871, 1872, 1873.						
Adapting Convict Jail for a manufactory	1,626	11	0			
Erecting cone-sheds	4,600	0	0			
Apparatus	2,441	11	3			
Do., carriage of	184	2	3			
Alcohol	689	6	5			
Do. carriage of	88	4	5			
Weighing machine	80	0	0			
Bark-presses	1,075	0	0			
Acid	514	1	0			
Soda	162	13	4			
Quick lime	100	0	0			
Cart-hire	406	12	3			
Vats	54	0	0			
Sanctioned establishment	2,792	2	11			
Extra labour	134	3	2			
Contingent expenditure	497	0	6			
Arbuthnot & Co., for landing charges, etc.	25	1	0			
				15,471	5	6
Total				27,206	5	8

BARK SUPPLY AND OUTTURN.

Ootacamund Manufactory.

	lbs.
1869-70.	
Bark supplied	17,793
Outturn.	
Amorphous quinine	21½
1870-71.	
Bark supplied	51,352
Outturn.	
Amorphous quinine	127

Nedivuttum Manufactory.

1871-72.

Bark supplied—		
Trunk	22,243	
Prunings	12,829	35,072
Outturn.		
Amorphous quinine		100
Bark supplied— 1872-73.		
Trunk...	33,841	
Prunings	46,440	80,281
Outturn.		
Amorphous quinine		215
Amorphous do. from the same bark		130½

No. 6. ORDER THEREON, 1st April 1874, No. 408.

Miscellaneous.

Surgeon-General, Indian Medical Department, Sanitary Commissioner, Commissioner of the Nilgiris, and Government Quinologist.

ORDERED to lie over, pending the receipt of the report from the Surgeon-General, Indian Medical Department, to G. O., dated 2nd March 1874, No. 286.

2. Copy of the foregoing will be communicated to the officers noted in the margin.

(True Extract.)

(Signed) C. G. MASTER,
Acting Secretary to Government.

To the Surgeon-General, Indian Medical Department.
,, the Sanitary Commissioner.
,, the Commissioner of the Nilgiris.
,, the Government Quinologist.

Exd. F. R. Bantleman.

Reports re Duty of State
26 of 1875 Mad

9-5-95
21-10-09
28-7-11

G. O., 1st April 1874, No. 408.

APRIL.
Nos. 4—6.

Quinologist's Report on Alkaloid Manufacture.—Defers passing orders on —, and directs a copy to be communicated to the officers concerned.

Ver 1377/74

Coïacamund
14th March 1874

No. — From

Mr. J. Broughton B. Sc. Lond. F.C.S.
Government Quinologist
Coïacamund

To

C. G. Master Esq.
Acting Secretary to Government
Revenue Department
Fort Saint George

Sir,

I have the honour as directed in G. O. No. 286 of 2d March 1874, to submit a statement of the total expenditure connected with the Alkaloid manufactory, the quantity of bark consumed, and the out-turn of "Amorphous quinine" since the year 1869.

2. In a report of December last I had the honour to detail the full cost connected with the manufactory during the year 1872-3 and extending to the time that the manufacture of the bark supplied during that year was completed. I also in that report entered fully into the various reasons which induced me to adopt the form of percolator I have since prepared, and the various hindrances and advantages connected with manufacture in India. Of the hindrances the most important is a purely artificial one which is due to the connivance of the Natives and the Superintendents of the Plantations, and not to the

of its cause, I allude to the "moxsing process", which has limited the supply of good bark to the manufactory to but four months of the year. As the objections to this method of cropping will shortly speak for themselves I need not further discuss them.

3. The figures I have now the honour to submit are therefore those more connected with a time when the manufacture was mainly experimental. This is specially the case with the details of the Ootacamund manufactory. They should not therefore be taken as those of a constant and current manufacture. The adaptation of a manufacture of a new substance to meet a special want to the conditions of an Asiatic country necessarily renders tentative work unavoidable. A constant and regular supply of bark to the manufactory, such as might be easily rendered would yet diminish the current cost of "Amorphous quinine" to a lower figure than I have hitherto been able to reduce it.

For a fuller discussion of the conditions of working and value of bark &c I must however refer to my report of December last. The bark has been almost exclusively that of C. Succirubra, much of which has been pruning of but small value, the weight of which of the green bark. The market

which is in a form quite unused in European medicine must depend on its intrinsic value. From the report of the Medical Inspector General it appears to have perhaps the same febrifuge effect as quinine Sulphate.

4. I fully coincide in the views stated by Mr. Howard in his letter accompanying G.O. N° 286 of 2d March with respect to the advisability of by degrees substituting Cinchonidine Sulphate for the quinine Sulphate. This will have the ultimate effect of raising the value of C. Succirubra bark, which otherwise will from its large production fall very low. I have stated this fully in my report of December 1873. From information I have gathered from Medical Officers in this country I am convinced that there is no risk of efficiency, but in some respects positive gain in the cautious substitution recommended by that Gentleman.

5. Mr. Howard also recommends that the C. Succirubra cultivation should partially be changed for that of C. Calisaya. I had the honour to recommend the same in my report of August 1873, attached to G.O. N° 208 of 15th December 1873, and remain entirely of the same opinion I then expressed. As the matter has been referred to the Commissioner of the Nilgiris for the opinion of the Superintendent of the Plantation

plantations. I am glad to have my recommendation corroborated by that of Mr. Howard.

6. The details I now submit are rendered briefer by the circumstance that I am preparing to leave India on the six months leave granted in G.O. of 22nd of 23rd January and have already commenced my preparatory leave from the 4th instant. The details however appear to contain all those requested by Government, and a full discussion of the question was submitted in December last.

I have the honour to be,
Sir
Your most Obed. Servt

J. Rice Broughton.
Govt. Quinologist

Statement showing expenditure incurred on the Alkaloid Manufactory during the Official years 1869–73 inclusive

Description of Charges	Cost			Total			Remarks
At Ootacamund 1869-70-71							
Buildings	7309	4	6				
Apparatus	750	12	11				
Water Supply	400	"	"				
Alteration of Press	160	"	"				
Alcohol	174	12	11				
Soda	20	"	"				
Acid	47	12	"				
Fuel	304	13	1				
Sanctioned Establishment	2108	5	7				
Contingent Expenditure	459	3	2	11735	"	2	
At Neddivattum 1871-72-73							
Adapting Convict Jail for a manufactory	1626	11	"				
Erecting Cone Sheds	4000	"	"				
Apparatus	2441	11	3				
do carriage of	184	2	3				
Alcohol	689	6	5				
do carriage of	88	4	5				
Weighing Machine	80	"	"				
Bark presses	1075	"	"				
Acid	514	1	"				
Soda	162	13	4				
Quick lime	100	"	"				
Cart hire	406	12	3				
Sacks	54	"	"				
Sanctioned Establishment	2792	2	11				
Extra labour	134	3	2				
Contingent Expenditure	497	"	6				
Rebullent &c. for landing charges &c	251	"	"	15471	5	6	
Total Rupees				27206	5	8	

Bark supply and Out-turn

Calacaunda Manufactory

1869-70

Bark supplied ____ lbs. 17793

Out-turn

Amorphous quinine ____ lbs. 212

1870-71

Bark supplied ____ lbs. 51352

" Out-turn

Amorphous quinine ____ lbs. 127

Neddiwatte Manufactory

1871-72

Bark supplied

Trunk ____ lbs. 22243

Prunings ____ 12,829 35072

Out-turn

amorphous quinine ____ lbs 180

1872-73

Bark supplied

Trunk ____ lbs 33841

Prunings ____ 46440 80281

Out-turn

Amorphous quinine ____ lbs 215

Amorphous quinine from the same bark ____ lbs 130¼

Ootacamund
December 1873

From, Mr. J. Broughton B.Sc. Lond. F.C.S.
Government Quinologist
Ootacamund

To, D. F. Carmichael Esq:
Secretary to Government
Revenue Department
Fort Saint George

Sir,

I have the honour in the following pages to make a report on the manufacture of alkaloid from the Cinchona bark of the Nilgiri Government plantations. The reasons for my adoption of that form of febrifuge alkaloid, named by the late Inspector General of Hospitals "amorphous quinine," and the mode of preparation of that substance, together with the present results from the manufactory at Neddivattum. In this report I will briefly recapitulate former statements and proceedings, in order that Government may have the matter fully before them.

2. My instructions from the Home Government given in September 1866 with reference to this part of my duties are as follows: (Cinchona Return 1870. page 4) "finally

Subject of Report

My original instructions

"finally it will be expected from the chemist
"that he should, through his investigations,
"enable her Majesty's Government to arrive
"at a decision with respect to the best and
"cheapest method of preparing the febrifuge
"for use among the labouring classes of the
"natives of India. He will also be required
"to consider the question connected with the
"manufacture of the cinchona febrifuge for the
"use of hospitals and troops in India."

3. Two years after my arrival in this country I obtained by experience, a knowledge of the advantages and defects of the cinchona species cultivated on the plantations. That of which the largest number of plants was cultivated was the C. Succirubra. This species has by far the most vigorous growth and still forms the most considerable part of the plantations. Though when young its bark yields much quinine, experience shews that the amount of this alkaloid diminishes with age. The main alkaloids of this plant however are cinchonidine and cinchonine. In gross amount of alkaloid in its bark this species is surpassed by few others. I became convinced from the small amount of quinine this species yields, and the difficulty with which it is obtained in a pure form that the Red

Red bark offered the least prospect of profitable demand by the European quinine manufacturer. I have therefore done my best in all reports, to check its cultivation, though in this respect I have been somewhat ineffectual, until too large a number had been planted. My estimate of the final low market value of this species is quite unchanged.

4. The reports of the Cinchona Commissioners in this and other Presidencies have however conclusively shewn that the other cinchona alkaloids possess a febrifuge power little, if at all inferior to that of quinine. This conclusion, though it was fully expected on chemical and historical grounds, is of the highest importance. It was this that led me to the adoption of the bark of C. Succirubra as a satisfactory material for the preparation of a febrifuge, which should be as effective as quinine sulphate.

5. The grounds on which I have long concluded that the febrifuge employed in the hands of Government for use in India, can be more cheaply prepared in this country have already been communicated (my letter attached to G.O. No. 249, of 7th February 1871.) They are briefly these:— The alkaloids are extracted with somewhat greater ease from the fresh

green bark than from dry. The necessity of drying, powdering and the freight of the bark to Europe is saved. The supply being in the hands of Government, allows a rougher and therefore cheaper mode of manufacture being adopted, than is usual in Europe for the preparation of the alkaloid sulphates. Against these there are of course considerable difficulties to be expected in the carrying out of any systematic process worked by natives; from the lonely situation of the plantations of Red bark, and the annoyances that consequently arise in such an undertaking in a manner almost peculiar to this country.

6. The actual cinchona bases being of course the active medicinal constituents in the sulphates or other salts employed as febrifuge, it was necessarily believed that the bases themselves would be as effective medicines as these salts. The considerable amount of tinctures and extracts of cinchona bark still employed in medicinal practice clearly shew the efficacy of salts other than sulphates, nor as far as I could learn do the preparations made from cinchona bark destitute of real quinine, shew any

explained by the results of the Madras Cinchona Commission. Pure quinine sulphate contains but 73.55 per cent of quinine. It was therefore believed that a preparation of the cinchona alkaloids, in the proportion that they naturally exist in the barks, which would contain about 97 per cent of the pure bases would admit of exactly the same medicinal doses being employed as of quinine sulphate. If there should be, for which there is no evidence, a somewhat inferior febrifuge quality in the alkaloids other than quinine, this would it was believed be compensated for by the larger amount of the real bases in the preparation, in comparison with quinine sulphate. The report of the Medical Inspector General attached to G.O. N.o 29 of 11th January 1871 appears subsequently to corroborate these suppositions, as he states it to be "a remedy in malarious "fever, scarcely, if at all inferior to quinine." The evidence for the belief expressed by the Government of Madras in para 3 of G.O. N.o 714 of 9th July 1872, I am unacquainted with.

7. Before describing the method of preparation I have adopted for the manufacture of the cinchona alkaloids I believe it will be of service if I detail with brevity various modes of preparation

preparation which it was necessary to try, and the objections that have arisen to each.

8. In a report appearing in Return on Cinchona Cultivation 1870, page 243 para. 54, and more fully in a memoir in Phil. Trans. Roy. Soc. 1870. I shew that six-sevenths of the alkaloids in the bark of C. Succirubra occur in the form of quino-tannates. As this salt is nearly insoluble in water, the presence of a strong acid is necessary for its decomposition, and complete solution of the alkaloid. It is this circumstance which constitutes the main difficulty in the preparation of alkaloid, since even after the tannates have been decomposed in hot or dilute solutions, they partially re-form when the same solutions become cold, or are increased in strength.

9. A method which has actually been employed in European manufactures and which possesses great simplicity, is the percolation of the dried and powdered bark by cold dilute acid, and the precipitation of the alkaloid, by caustic soda. It will be perceived that this method either compels one to forego the advantage of obtaining the bark in its fresh green state or renders a complete preliminary coaling necessary. However carefully

jections to it were that a large and expensive amount of acid was necessary for the nearly complete extraction of the alkaloid, which had subsequently to be neutralized with soda, and that on a manufacturing scale only two-thirds of the total amount of alkaloid was ever obtainable, and then not by any means in a pure state. The concentration of the bulky solution by evaporation increased the latter evil. In India the utmost possible economy in the use of acid is necessary.

10. I may here state that I prepared the crystallized sulphates of quinine and cinchonidine from fresh red bark by digestion in the cold with dilute sulphuric acid, and neutralization and evaporation of the extract. It was with great regret, that after much trial I found it impossible to obtain more than a quarter of the total sulphates by this very simple method.

11. A method of manufacture which though I finally abandoned it, has the great advantage of not requiring the use of alcohol may be here briefly described. An extract is made by boiling the bark in the usual manner with 4% per cent of sulphuric acid. When the bark is exhausted the extracts are evaporated to dryness and kept for half an hour at a temperature of 120° C. This completely decomposes the

the quino-tannic acid. The solid residue is powdered exhausted with water filtered, and the alkaloid precipitated with caustic soda. It is thus obtained tolerably pure, though one third of the amount is lost, and much of the alkaloid is converted into the non crystallizable isomerides.

12. The method of Clark, and many others were also carefully and quantitatively tried, but the results led to their abandonment. Mineral oils &c were also experimented with, to use in the place of alcohol but without economical success.

Clarks and other methods

13. The method of Delondre, which before I came to India had been tried by Mr Markham (for the preparation of "quinium") was also fairly tried by me, Cinchona Return 1866, page 218. It consists in mixing the powdered bark with calcic hydrate and water, drying and exhausting with alcohol. Nearly the whole of the alkaloid is thus obtained mixed with much resin and calcic salts, from which however it can be afterwards purified. The necessary preliminary fine division of the bark is a disadvantage of this process, but the most serious is the waste of alcohol which it entails it being found

Delondre's method

found very difficult to wash out the spirit from the spent bark as the latter swells up immediately water is applied. In extremely rich barks, the method would be applicable but with poor barks, the great waste of spirit in proportion to the amount of alkaloid obtained renders the method quite unfit for the preparation of a cheap febrifuge. It consequently has to be abandoned as I believe is now the case in the Havre manufactory.

14. The method I have adopted is quite similar in principle to the usual method that since the time of Pelletier has prevailed in manufactories of Cinchona alkaloids. It consists in precipitating the alkaloids in an insoluble state, and subsequently separating them from the mass of impurities with which they are mixed by solution in alcohol. The method is however so contrived, that the very cheapest materials are used and the greatest economy is practicable with those materials which are not found on the plantations. The only material of which the consumption is large, is that of wood fuel, which some years ago it was believed would be furnished in any amount by the Cinchona plantations, by trees which had been coppiced. This however has not been the case, owing to the adoption of Mr Mc Ivor's system of mossing, respecting which I have already expressed an opinion which I need not further reiterate.

Principle of method

The

15. The process was first tried in my small laboratory at Ootacamund, and I found that from 80 to 95 per cent of the total amount of alkaloid in the bark was obtained by it. If done with analytic precision, which of course cannot be practically carried out in a manufactory, 97.1 per cent of that amount is obtainable; though I have never obtained this result when working with native coolies, but only when the work was performed by myself or by my laboratory assistant.

16. The first product of this process, named by the late Principal Medical Inspector General "Amorphous quinine" was prepared in the small experimental manufactory erected at Ootacamund, where enough was prepared from red bark grown at Neddivattum for a fair trial of its medical efficacy. The results of its medical trial are contained in a report of the Principal Medical Inspector General attached to G.O. No. 29 of 11th January 1871. which were considered highly favourable.

17. I will now describe the method of manufacture I have adopted which though in the course of work has been constantly modified and improved is of course susceptible of further improvements in detail.—

The bark in long strips exactly as taken

from the tree is placed in a copper pan with 1½ per cent of sulphuric acid* and a quantity of water that has already been used for the fourth extraction of nearly spent bark and boiled for an hour. The liquid and bark are then separated by strong pressure in a screw press, the former falling in a wooden vat placed underneath. The squeezed and nearly dry bark is again boiled with liquid that has been used for a third boiling of other bark and another half per cent of acid is added. After an hours boiling it is again squeezed. It is then again boiled with a liquid that has come off nearly spent bark, again squeezed, and finally boiled with water. During these four boilings the bark after each squeezing diminishes greatly in bulk, and becomes almost pulp, so that it occupies far less room in a pan at the third boiling to what it did at the first. The order in which the several liquids used in extraction are employed, depends on the qualities of bark under manufacture, but it is so arranged as to obtain finally a liquid containing as much alkaloid as possible in solution, and also that as far as possible the bark should be exhausted of alkaloid. Finally there arrives a point when the amount of alkaloid in the bark has become so small as not to repay the expense of further extraction.

* This is the amount of acid employed for trunk bark, for prunings but 1 per cent or even less is ordinarily used.

extraction. The bark then is dried in the sun and used as fuel.

18. The liquid, which if the foregoing be judiciously managed should be intensely bitter and strong, is evaporated to about one-sixth of its bulk transferred to a tub and allowed to cool. It is then decomposed by neutralization with milk of lime which precipitates the alkaloids, decomposing the quinotannates and sulphates with formation of insoluble lime salts. A slight excess of lime is always added. After standing for a day the precipitate is separated by filtration, squeezed dried and powdered in a common rice mill. The liquid which contains abundance of calcic quinate in solution is thrown away.

19. As first conducted, the evaporation mentioned in the foregoing para was omitted, the precipitation being at once performed in the original liquid. But as alkaloid is unfortunately slightly soluble in lime water this proceeding was found to produce considerable waste and therefore it was found necessary to evaporate in order to reduce this waste to a minimum. In India lime must necessarily be the precipitant as it is by far the cheapest of all the alkaline bases. I have tried both caustic

English caustic soda, and Indian soudoo as precipitants of the alkaloid, but for many reasons do not now employ them.

20. The powdered lime precipitate is then packed in the apparatus of which a drawing is given. ABCD. being a large cone of sheet iron through the centre of which passes an upright tube, the upper end of which terminates in a cross-piece with four openings. The lower end of the tube is also open and supplied on a flat perforated circular disk C.D. made of sheet iron. This allows it to rest in the cone. Below and tightly fitting to the lower part of the cone is an under copper vessel F.G. The cone is supported by chains and above it is placed in connection with the lower end of a simple worm-tub, (not shewn in the drawing) by means of a tube H. The powdered lime precipitate is filled in the cone till immediately under the cross tube E. the upper lid of cone is fitted on and alcohol poured on till by passing through the precipitate the lower vessel becomes about a third full. The spirit is then saturated with alkaloid which is neutralised with care by diluted sulphuric acid of which the strength is known. Then the upper lid of the

the cone is put into connection with the upper condenser by the tube E. and a fire is lighted below. The spirit boiling in F.G. rises in vapour through the inner tube and passes out at the four openings of the cross-pieces. It here generally condenses to a liquid, but if not it passes into the copper condenser, where it of course condenses, so that by a judicious arrangement of the fire a layer of liquid is kept on the surface of the precipitate. A gauge B.I. allows this to be seen from the outside. If the fire is however kept too fierce no harm can ensue, since if the layer of liquid rises in consequence higher than the percolation through the precipitate removes it, it simply passes down through the centre tube into the lower vessel. Hence the apparatus is self-acting and the coolie workpeople have no connection with the alcohol, which is all inside the apparatus. A small amount of alcohol by constant circulation through the apparatus, thus completely dissolves the whole of the cinchona bases, without any waste of spirit or alkaloid. Every two days the alkaloid is neutralized with dilute acid. If this be done with moderate care, there is no chance of the copper under vessel being in the least attacked, but if very carelessly done a mere trace of oxide of copper is dissolved. This however rarely occurs, but if it does, it is readily remedied subsequently.

21. The fire is thus kept up until the whole of the alkaloid is dissolved, and passes into the lower vessel. This state of things is known by the alkalinity of the liquid in the lower vessel not increasing. But to make sure, the spirit dropping from the cone is usually tested when the process draws near its end. When finished the exhausted precipitate does not contain a trace of alkaloid, all being in the lower vessel. The lower vessel is then removed and the alcohol separated by distillation. Water is also poured on the cone, in order to wash out the alcohol with which the precipitate is still moistened, until the latter is quite removed. The alcohol is thus nearly all recovered, and is purified for another operation by distillation. With care waste of spirit practically does not occur, but I have been unable yet to prevent all loss of spirit, from the carelessness with which every operation in this country appears more or less attended. The loss however has not exceeded six per cent, and has fallen frequently much below this.

22. The alkaloid sulphates in the lower

lower vessel is suddenly diluted with about ten times its bulk of cold water. This separates a considerable amount of black resin. Separation and precipitation of alkaloid

Since the contamination of copper occurred in Bengal in the alkaloid, I have always as a precaution added a small amount of a dilute acidulated solution of sodic sulphide to the liquid. This completely removes copper if it be present, though with very moderate care it is completely unnecessary. The solution is still however coloured with impurities, to remove which a small amount of alkaloid is precipitated by the addition of dilute caustic soda, which carries down with it the colouring matters. The whole is then filtered through a cloth bag, and the alkaloid in the filtrate is precipitated by caustic soda, separated by filtration, squeezed dried and powdered. It is then "amorphous quinine". Before it leaves the manufactory as a precautionary measure it is always tested for copper.

23. Formerly, from the ashes of the fuel employed, caustic potash was prepared to use as precipitant instead of soda. But lately so small an amount of potash has occurred in the ashes, that this has been discontinued. If the cinchona wood from coppiced

coppiced trees was employed as fuel, this might be again resumed and thus a further saving effected.

24. Sulphuric acid has been used in preference to hydrochloric acid mainly because it is the cheaper acid. While the cost is nearly like sulphuric acid is for the same, the effective power of extraction of work produced by the sulphuric acid is nearly double that of hydrochloric acid for equal weights. It has also some better qualities for transit through the tropics. The use of sulphuric acid has also some chemical advantages which I need not further particularize. With Red bark, there is unfortunately no fear of the sudden crystallization of quinine sulphate on the dilution mentioned in para. 22 as there would be with Crown bark.

25. The alkaloid which is carried down in connection with the precipitated resin, and in the purification by fractional precipitation is of course from time to time obtained free from impurities by the obvious methods of drying and digestion with dilute acids &c. Thus obtained it is generally very pure and colourless. alkaloid contained in the resin is not wasted

26. Throughout the whole course of manufacture simplicity of arrangement has been carried out as far as possible. The reasons for this are. simple apparatus throughout have been preferred

1st That certain labour-saving appliances which are used in Englad would here be a source of considerable expense, and are obtainable with great difficulty and delay. Until alkaloid manufacture in South India has proved itself a permanent success I have therefore felt it wiser to refrain from all dispensable expenditure, for apparatus for which simple substitutes could be provided. 2nd That the simpler the apparatus the more readily are they repaired when necessary in India. 3rd The intelligence of Kanarese coolies on the Nilgiris is fully exercised by the simplest proceedings of manufacture, therefore any increase in their apparent complexity has to be made with a risk of loss, and injury to the apparatus.

27. The whole of the trunk bark supplied to the manufactory during the year 1872-3 has been obtained under the coppicing system which has virtually been adopted by the Madras Govt. This method of cropping bark has the disadvantage of only permitting the supply of good bark to be furnished during the two months at the beginning and the two months that end the monsoon. Hence during that time the pressure of work is very considerable while during the remainder of the year it is very light,

Trunk bark is only supplied at beginning and end of monsoon

so that I have been glad at the latter period to work with very inferior prunings, for the purpose of keeping the establishment employed, although I knew such bark could not be worked with profit.

28. Though I am aware the refraining from coppicing cannot be permanent, it has had a further result for which at the commencement of manufacture I was unprepared. At that time I believed the supply of fuel from the plantation would be unlimited from the coppicing of the trees. But up to the present time as coppicing has not been practically carried out, no fuel has been obtained from the Cinchonas. The fuel hitherto employed, has been furnished by the trunks and branches of trees that once formed part of the original shola on whose site the plantations were formed, and now lie among the cinchona trees. In a short time this source of fuel will be exhausted, and is now a more costly fuel than cinchona wood would be.

Plantations have not supplied fuel for manufacturing

29. I will now state the results that have been obtained in the year 1872-3 in the manufacture of cinchona alkaloid and the actual cost of preparing the same.

30. I should state that a nine recent examination of returns has shewn that the 3613 lbs of officinalis pruinings mentioned in my annual report (para. 2 G. B No. 714 of 9th July 1873) had previously been included in the 46440 lbs stated as Red Bark pruinings, and thus were mentioned twice over. The correction will therefore reduce the total amount of bark supplied to the manufactory by 3613 lbs. I mention this for the sake of accuracy, though the difference to the amount of alkaloid due is but 4½ lbs.

A correction of the amount of bark supplied

31. I have the honour to give in appendix to this report, a statement of the actual expenditure subsequent to last official year that has been necessary to work up the unfinished product of that year, which was in the state described in para. 18, or lime precipitate. The pay of the superintendant is not included, as during the time he has been mainly occupied in extracting fresh bark, and during the similar early part of 1872-3 he might have been similarly occupied in working up the lime precipitate of the previous working season had any remained. Every working expense has however been charged that has been required for the preparation of the alkaloid fit for sending to the Medical stores Madras. No repairs of apparatus have been required. All the resin, pasteral precipitates &c. have had the alkaloid separated in order to ascertain the true result of the work of 1872-3, so that nothing is assumed or estimate.

Superintendants pay not charged in subsequent expenses

32. From the lime precipitate obtained during the last official year that remained for exhaustion with alcohol 130 lbs 11 oz of amorphous quinine have been obtained. This is a little less than I at first expected and stated in my annual report. My estimate was founded on the amount of lime precipitate that remained treatment, the yield of which was fairly assumed to be the same as that worked up in the year. I therefore hoped that a quantity of alkaloid not very far below the theoretical amount could be obtained. I now find that lime precipitate from pro-

Amount of amorphous quinine obtained from lime precipitate

pruinings, like those worked up during the latter part of last year, contains far less alkaloid than that obtained from good bark. The extra expenditure necessary for obtaining this 130 lbs 11 oz, is however but small being but 1 anna, 8 pies per ounce.

33. In order to determine the true total yield of the barks that were supplied in 1872-3 I have placed in appendix the results of the many analyses that have constantly been made during the year. These have been performed as far as possible on a carefully selected average sample of each kind supplied. The results of these multiplied by the respective weights of the barks will express clearly the total yield of the bark supplied. The total shews that 537.9 lbs was contained in the whole of the bark. The total weight of alkaloid obtained in manufacture is 345.68 lbs.

Analyses of total barks supplied

34. It must not be supposed that it is possible in manufacture to obtain the same results as are obtained in analysis, as any typical methods of procedures cannot be carried out on a large scale, — even if the cost permitted. Whether manufacturers have ever compared the theoretical yield of total alkaloids in the bark worked, with the actual amounts they obtain in manufacture I do not know; but there is no record of their having done so. Quinine manufacturers are only specially interested in obtaining all the quinine from the bark, and would have no great care for the other alkaloids, which at the time I left Europe usually accumulated on their hands unsold. It is therefore probable that a comparison such as I have made, is made for the first times. It is on this account I have been anxious to have it as complete as possible, and hence the delay in the submission of this report.

Total alkaloids obtained in manufacture

35. I will indicate the causes of the loss of alkaloid which occur in the manufacture, nearly the whole of which are preventible, only at a greatly increased cost of labour and product.

, as the not quite complete exhaustion of the bark of alkaloid on first extraction with acidulated water. Usually the bark at the end

of the bilings described in para. 16 of this report still contains a small amount of alkaloid which another boiling and squeezing would remove. This is not now performed, as the small amount of alkaloid obtained would not repay the cost of the labour, fuel and subsequent evaporation

2nd Spilling and waste of extract and occasionally of bark itself by the carelessness and indifference of the coolies. This is not preventible in India.

3rd Waste of material in grinding the lime precipitate and in final powdering of the alkaloid. This may with care and training be diminished but cannot entirely be obviated.

4th The solubility to a small extent of the alkaloids in lime water. At the beginning of the year 1872-3 loss from this source occurred. It has since, as I have before mentioned, been prevented by the evaporation of the liquid extract of bark down to a small bulk, before the precipitation with milk of lime is performed. I cannot fairly estimate the amount of waste that has occurred from this source, but believe it will not have exceeded 20 lbs of alkaloids.

36. As a measure of precaution I have repeatedly tested whether the lime precipitate is completely exhausted of alkaloid by the alcohol before throwing it away, and have always found that no alkaloid is wasted by imperfect exhaustion, as might otherwise be naturally supposed.

37. I will now state the total cost of manufacturing the alkaloids. In appendix I give a statement of all the expenditure connected with the works for the working up of the bark supplied during the year 1872-3. This excludes the cost of apparatus and repairs, the latter expense being however but small. It also excludes any more pay, as manufacturing work can go on, after machinery established under the superintendant, without the necessity of a chemists intervention. During the year my time has been more occupied with other duties than with the alkaloid works at Nedoolmittoor, which I visit but weekly.

38. The total expenses therefore have been Rs 282-8-11-9 and 345 lbs 11 oz of amorphous quinine have been obtained. This shews that the expense of preparing each ounce has been 8 as 2 pies. This does not of course include the cost of the barks, but is that of manufacture only. This cost is within my original estimate (letter attached to G.O. No. 249, 7th Sept. 1871). This estimate was framed on the assumption that 800 lbs were manufactured, and that the barks worked had a mean yield of 4 per cent of alkaloid when dry. The bark supplied in 1872-3 has had a mean percentage of scarcely 3, on account of the large quantity of nearly worthless bark from Pennys supplies during the dry weather, which frequently contained but 0.5 per cent of alkaloid when dry. The results of manufacture on the score of cost appear therefore satisfactory.

39. Government Order No. 714 of July 9th 1873 directs me the honours of requesting my matured opinion on the expediency of manufacturing any febrifuge in this country. Before doing expressing this, I beg respectfully to make some remarks on para. 3 of the same G.O.

40. In this para. it is accurately stated that 1/- per pound may be taken as the value of (green) Red Bark, basing this estimate on the despatch from His Grace the Secretary of State, recorded in G.O. No. 1429 of the 16th Oct. 1872 in which it is stated that (commercially dry) Red Bark sold at from 2/- to 3/1 per pound in England. This of course would be the value of the dried and packed after arrival at Homes. But if the manufactory be charged the English price for bark grown on the spot in India, it will follow that the febrifuge must be produced at something near the English price of quinine sulphate, or as the G.O. states the cost of the alkaloid will be Rs 3-9-6 per ounce. The present English price of quinine sulphate is 9/6 per ounce, or roughly

Rs 4-12-0. If the Madras Government therefore desire the profit on the sale of Cinchona bark at the present English prices, it must not expect at the same time a febrifuge for Indians use at the price of Rs 1 per ounce.

41. I will again state the reasons that to me appear convincing, why the present English price of Red Bark cannot continue. This bark, whether renewed under moss or not, is nearly unfitted for the manufacture of quinine, as it contains so little, and that little is difficult to obtain as crystallized sulphate. It is used for the manufacture of tinctures and other pharmaceutical preparations.

Reasons why the prices of Red Bark will decline.

I am informed on good authority that annually 100.000 lbs of cinchona bark are used for these purposes in England. Without counting the Government plantations, the private plantations of the Nilgiris contain nearly a million and a half of trees of C. succirubra, which will in a short time supply at least fifteen times that amount annually. To this must be added the yields of the private plantations in Bengal and in other parts of the world. I cannot but conclude, that with this enormous supply, the price of Red Bark must very shortly fall in the English market, till it only just pays for the cultivation and export. It is quite possible that the employment of cinchonidine and cinchonine in medicine may hereafter give Red Bark a certain manufacturers value, but much time must elapse first. At the present time the qualities of Indian Red Bark are scarcely known in England but they will shortly become so. The foregoing are therefore the reasons, as I before stated, on which my choice of the genus of febrifuge, and the bark from which it is to be obtained, are mainly founded.

42. But for a short time to come, the value of the bark attributed to it by Government will doubtless be the main influence in their estimate of the expediency of manufactures in South India. In all papers previous

English preparations are incompatible with the presence of

to G. B. No. 714 of July 9th it appears to be implied that the actual cost price of the bark on the plantations, should be the element of cost in that of the alkaloid. If the present price obtained by the sale of bark in England be debited to the alkaloid manufactory for its raw material, it is quite clear that a cheap febrifuge will be impossible, and I could have previously stated this before coming to India. The profit of sale, and cheapness of febrifuge cannot coexist. If all the barks whose alkaloids will finally be used in India be exported, the additional and apparently unnecessary labours of drying, packing, transport and sale of bark will be taken; and the advantages of the control of manufactures will be sacrificed which permits a more abundantly occurring form of febrifuge to be used in India. It is for His Excellency the Governor in Council to determine whether the profit of sale of Red Bark in England, or cheapness of febrifuge for use in India be the end to be obtained.

43. My matured opinion therefore does not differ from the one I formerly expressed concerning alkaloid manufacture in India (letter recorded in G. B. No. 249 of 7th Feb.y 1871). But under any circumstances as long as Government export Red Bark, advantage will be found in having some means of obtaining the alkaloid contained in the bark of prunings and waste bark that is not worth carriage to England; which must always occur on the plantations in considerable quantities. Therefore if my opinion is not held by Government, the small manufactory now established in Madras to cause the extract must contain actions will still have work.

44. I could suggest that if any doubt is felt of the medicinal efficacy of amorphous quinine, after the original report of the Inspector General of Hospitals recorded in G. B. No. 29 of 11th Jan.y 1871, that a further expression of the opinion of three medical Authorities on the same should be called for by Government.

I suggest further inclusion of report on amorphous quinine.

I have the honour to be
Sir,
Your most obedient servant
John Broughton
Government Deimologist

Potacammund
Dec.r 4, 1878

Cost of Alkaloid manufacture from the Cinchona bark supplied during the year 1872–3

Description of Charges	Cost			
In Year 1872—3.				
Pay of Superintendent and Coolies	174	8	"	
Extra Labour	62	15	6	
Contingent expenses	102	11	6.	
Fuel	82	"	"	
Lime	72	8	"	
Carriage of Alcohol and lime	33	10	9	
Cost of Alcohol used	90	"	"	
do. Acid sent out by India Office	407	"	"	
do. Soda	19	13	10	
Subsequent Expenses				
Cost of collecting fuel	37	3	"	
Labour	56	8	6	
Soda	9	13	6	
Alcohol	84	0	8	
Acid	6	5	"	
Oil	11	9	4	
Cost of powdering the alkaloid	3	"	"	2823 11 9
Total Rupees				2823 11 9

Succirubra

Bark

		Bark sent green	Per cent dry	Weights dry bark	Per cent of alkaloid	Weight of alkaloid
1st April to 20th May 1872						
Neddivattum	Trunk	943	30	282	4.1	15.5
"	Prunings	10				
20th May to 18th June						
Neddivattum	Trunk	2118	28	612	7.1	43.4
18th June to 3d July						
Neddivattum	Trunk	3140	29	910		38.2
3d July to 18th July						
Neddivattum	Trunk	2184	29	633	5.1	32.2
18th July to 7th October						
Neddivattum,	Trunk *	7767	30	2330	4.8	111.8
7th October to 16th October						
Neddivattum	Trunk	7357	26.8	1971	4.3	84.7
"	Prunings	814	25	203	1.7	3.4
16th October to 24th October						
Neddivattum	Trunk	2679	25.8	691	3.5	24.1
"	Prunings	533	25	133	2.6	3.4
24th October to 4th November						
Neddivattum	Trunk	3860	27.7	1071	4.3	46.0
"	Prunings	4749	24	1139	2.6	29.6
Pykara	Trunk	958	27	258	5.0	12.9
"	Prunings	1480	25	370	1.6	5.91
4th November to 21st Nov.						
2 Neddivattum	Trunk	24	28	6	5.0	0.3
"		750	27	202	5.2	10.5
Pykara	Prunings	1486	25	317	1.5	5.5
21st Nov. to 13th December						
Neddivattum	Trunk	22	27	6	4.0	0.2
"	Prunings	66	25	16	2.2	3.5
Pykara	Trunk	1419	27	383	4.0	15.3
"	Prunings	4875	25	1219	1.1	13.4
13th Dec. to 9th January 1873						
Neddivattum	Prunings	1251	25	312	1.8	5.6
Pykara	"	7100	24	1700	0.5	8.5
9th Jan. to 10th January						
Neddivattum	Prunings	135 / 4505	25	148	0.7	1.0
Pykara	"					
10th Jan. to 27th January						
Neddivattum	Prunings	1671 / 5147	24	1636	0.5	8.1
Pykara	"					
27th Jan. to 24th February						
Neddivattum	Prunings †	7603	25	1900	0.6	11.4
Pykara	"					
24th February to 3d March						
Pykara	Prunings	1890	25	472	0.5	2.3
3d March to 18th March						
Neddivattum	Prunings	1147 / 2520	not worked			
Pykara	"	450	27	121	1.0	1.2
Prunings of C. Calisaya		3613	Nearly worthless			
Prunings of C. Officinalis						
		80281		19041	79.5	537.9

* 600 lbs. from decayed trees
† 3613 lbs. of prunings of C. Officinalis have here been deducted

From
The Govt. Quinologist
Ootacamund

To
The Secretary to Govt.
Revenue Department
Fort St. George

Dated 1/12 Dec. 1873
Rec'd

Rev 3881/73

Report on Alkaloid Manufacture

No 408 / 1 statistics
Dec 13 1873

Read the following letter 597

The following letter from J. BROUGHTON, Esq., Government Quinologist, to D. F. CARMICHAEL, Esq., Secretary to Government, Revenue Department, Fort St. George, dated Ootacamund, 1st December 1873:—

I HAVE the honour to enclose a report on the manufacture of alkaloid from the Government Cinchona Plantations at Neddivuttum, and beg permission to be allowed to correct the proofs of the same before publication.

2. I further request that I may be allowed to have four copies of the same.

From J. BROUGHTON, Esq., B. Sc. Lond., F.C.S., Government Quinologist, to D. F. CARMICHAEL, Esq., Secretary to Government, Revenue Department, Fort St. George, dated Ootacamund, 1st December 1873.

I HAVE the honour in the following pages to make a report on the manufacture of alkaloid from the Cinchona bark of the Nilgiri Government Plantations, the reasons for my adoption of that form of febrifuge alkaloid, named by the late Inspector-General of Hospitals "Amorphous quinine," and the mode of preparation of that substance, together with the present results from the manufactory at Neddivuttum. In this report I will briefly recapitulate former statements and proceedings, in order that Government may have the matter fully before them.

Subject of Report.

2. My instructions from the Home Government, given in September 1866, with reference to this part of my duties, are as follow (Cinchona Return, 1870, page 4), "Finally, it will be expected from the Chemist that he should, through his investigations, enable Her Majesty's Government to arrive at a decision with respect to the best and cheapest method of preparing the febrifuge for use among the labouring classes of the natives of India. He will also be required to consider the question connected with the manufacture of the Cinchona febrifuge for the use of hospitals and troops in India."

My original instructions.

3. Two years after my arrival in this country I obtained, by experience, a knowledge of the advantages and defects of the Cinchona species cultivated on the plantations. That of which the largest number of plants was cultivated was the *C. Succirubra*. This species has by far the most vigorous growth and still forms the most considerable part of the plantations. Though, when young, its bark yields much quinine, experience shows that the amount of this alkaloid diminishes with age. The main alkaloids of this plant, however, are Cinchonidine and Cinchonine. In gross amount of alkaloid in its bark this species is surpassed by few others. I became convinced from the small amount of quinine this species yields, and the difficulty with which it is obtained in a pure form, that the red bark offered the least prospect of profitable demand by the European quinine manufacturer. I have, therefore, done my best in all reports to check its cultivation, though in this respect I have been somewhat ineffectual, until too large a number had been planted. My estimate of the final low market-value of this species is quite unchanged.

Alkaloids of red bark mainly not quinine.

4. The reports of the Cinchona Commissioners in this and other Presidencies have, however, conclusively shown that the other Cinchona alkaloids possess a febrifuge power little, if at all, inferior to that of quinine. This conclusion, though it was fully expected on chemical and historical grounds, is of the highest importance. It was this that led me to the adoption of the bark of *C. Succirubra* as a satisfactory material for the preparation of a febrifuge which should be as effective as quinine sulphate.

Influence of reports of the Cinchona Commission.

5. The grounds on which I have long concluded that the febrifuge employed in the hands of Government for use in India can be more cheaply prepared in this country have already been communicated (my letter attached to G. O., No. 249, of the 7th February 1871). They are briefly these: The alkaloids are extracted with somewhat greater ease from the fresh, green bark than from dry. The necessity of drying, powdering, and the freight of the bark to Europe is saved. The supply being in the hands of Government allows a rougher and therefore cheaper mode of manufacture being adopted than is usual in Europe for the preparation of the alkaloid sulphates. Against these there are, of course, considerable difficulties to be expected in the carrying out of any systematic process worked by natives, from the lonely situation of the plantations of red bark and the annoyances that consequently arise in such an undertaking in a manner almost peculiar to this country.

Reasons for manufacturing alkaloids in India.

6. The actual Cinchona bases being, of course, the active medicinal constituents in the sulphates or other salts employed as febrifuge, it was necessarily believed that the bases themselves would be as effective medicines as these salts. The considerable amount of tinctures and extracts of Cinchona bark still employed in medicinal practice clearly show the efficacy of salts other than sulphates, nor, as far as I could learn, do the preparations made from Cinchona bark destitute of real quinine show any failure in febrifuge efficacy, a fact readily explained by the results of the Madras Cinchona Commission. Pure quinine sulphate contains but 73·55 per cent. of quinine. It was, therefore, believed that a preparation of the Cinchona alkaloids, in the proportion that they naturally exist in the barks, which would contain about ninety-seven per cent. of the pure bases, would admit of exactly the same medicinal doses being employed as of quinine sulphate. If there should be, for which there is no evidence, a somewhat inferior febrifuge quality in the alkaloids other than quinine, this would, it was believed, be compensated for by the larger amount of the real bases in the preparation in comparison with quinine sulphate. The report of the Medical Inspector-General, attached to G. O., No. 29, of the 11th January 1871, appears subsequently to corroborate these suppositions, as he states it to be "a remedy in malarious fever, scarcely, if at all, inferior to quinine." The evidence for the belief expressed by the Government of Madras in paragraph 3 of G. O., No. 714, of the 9th July 1872, I am unacquainted with.

Therapeutical considerations and results.

7. Before describing the method of preparation I have adopted for the manufacture of the Cinchona alkaloids I believe it will be of service if I detail with brevity various modes of preparation which it was necessary to try and the objections that have arisen to each.

Methods of manufacture considered.

8. In a report appearing in Return on Cinchona Cultivation, 1870, page 243, paragraph 54, and more fully in a Memoir in Phil. Trans. Roy. Soc., 1870, I show that six-sevenths of the alkaloids in the bark of *C. Succirubra* occur in the form of quino-tannates. As this salt is nearly insoluble in water, the presence of a strong acid is necessary for its decomposition and complete solution of the alkaloid. It is this circumstance which constitutes the main difficulty in the preparation of alkaloid, since, even after the tannates have been decomposed in hot or dilute solutions, they partially re-form when the same solutions become cold or are increased in strength.

Alkaloids exist in bark as insoluble quino-tannates.

9. A method which has actually been employed in European manufactures, and which possesses great simplicity, is the percolation of the dried and powdered bark by cold dilute acid and the precipitation of the alkaloid by caustic soda. It will be perceived that this method either compels one to forego the advantage of obtaining the bark in its fresh, green state or renders a complete preliminary crushing necessary. I, however, carefully and repeatedly tried the method. The objections to it were that a large and expensive amount of acid was necessary for the nearly complete extraction of the alkaloid, which had subsequently to be neutralized with soda, and that on a manufacturing scale only two-thirds of the total amount of alkaloid was ever obtainable, and then not by any means in a pure state. The concentration of the bulky solution by evaporation increased the latter evil. In India the utmost possible economy in the use of acid is necessary.

Method of percolation with dilute acid.

10. I may here state that I prepared the crystallized sulphates of quinine and Cinchonidine from fresh red bark by digestion in the cold with dilute sulphuric acid and neutralization and evaporation of the extract. It was with great regret that after much trial I found it impossible to obtain more than a quarter of the total sulphates by this very simple method.

Crystallized sulphates of quinine and Cinchonidine can be obtained by the foregoing method modified.

11. A method of manufacture which, though I finally abandoned it, has the great advantage of not requiring the use of alcohol may be here briefly described. An extract is made by boiling the bark in the usual manner with four per cent. of sulphuric acid. When the bark is exhausted the extracts are evaporated to dryness and kept for half an hour at a temperature of 120° C. This completely decomposes the quino-tannic acid. The solid residue is powdered, exhausted with water filtered, and the alkaloid precipitated with caustic soda. It is thus obtained tolerably pure, though one-third of the amount is lost, and much of the alkaloid is converted into the non-crystallizable isomerides.

Method by heating the extract to 120° C.

12. The method of Clark and many others were also carefully and quantatively tried, but the result led to their abandonment. Mineral oils, etc., were also experimented with to use in the place of alcohol, but without economical success.

Clark's and other methods.

13. The method of Delondre, which before I came to India had been tried by Mr. Markham (for the preparation of "quinium") was also fairly tried by me (Cinchona Return, 1866, page 218). It consists in mixing the powdered bark with calcic hydrate and water, drying and exhausting with alcohol. Nearly the whole of the alkaloid is thus obtained mixed with much resin and calcic salts, from which, however, it can be afterwards purified. The necessary preliminary fine division of the bark is a disadvantage of this process, but the most serious is the waste of alcohol which it entails, it being found very difficult to wash out the spirit from the spent bark as the latter swells up immediately water is applied. In extremely rich barks the method would be applicable, but with poor barks the great waste of spirit in proportion to the amount of alkaloid obtained renders the method quite unfit for the preparation of a cheap febrifuge. It consequently had to be abandoned, as I believe is now the case in the Havre Manufactory.

Delondre's method.

14. The method I have adopted is quite similar in principle to the usual method that since the time of Pelletier has prevailed in manufactories of Cinchona alkaloids. It consists in precipitating the alkaloids in an insoluble state and subsequently separating them from the mass of impurities with which they are mixed by solution in alcohol. The method is, however, so contrived that the very cheapest materials are used and the greatest economy is practicable with those materials which are not found on the plantations. The only material of which the consumption is large is that of wood fuel, which some years ago it was believed would be furnished in any amount by the Cinchona plantations by trees which had been coppiced. This, however, has not been the case, owing to the adoption of Mr. McIvor's system of mossing, respecting which I have already expressed an opinion which I need not further reiterate.

Principle of method in use.

15. The process was first tried in my small laboratory at Ootacamund, and I found that from eighty to niney-five per cent. of the total amount of alkaloid in the bark was obtained by it. If done with analytic precision, which, of course, cannot be practically carried out in a manufactory, 97·1 per cent. of that amount is obtainable, though I have never obtained this result when working with native coolies, but only when the work was performed by myself or by my Laboratory Assistant.

Experimental results of method.

16. The first product of this process, named by the late Principal Medical Inspector-General "Amorphous quinine," was prepared in the small experimental manufactory erected at Ootacamund, where enough was prepared from red bark grown at Neddivuttum for a fair trial of its medical efficacy. The results of its medical trial are contained in a report of the Principal Medical Inspector-General attached to G. O., No. 29, of the 11th January 1871, which were considered highly favourable.

First trials of manufacture.

17. I will now describe the method of manufacture I have adopted, which though in the course of work has been constantly modified and improved, is, of course, susceptible of further improvements in detail.

Description of method now employed. Extraction of bark.

The bark in long strips, exactly as taken from the tree is placed in a copper pan with 1½ per cent. of sulphuric acid* and a quantity of water that has already been used for the fourth extraction of nearly spent bark boiled for an hour. The liquid and bark are then separated by strong pressure in a screw press, the former falling in a wooden vat placed underneath. The squeezed and nearly dry bark is again boiled with liquid that has been used for a third boiling of other bark and another half per cent. of acid is added. After an hour's boiling it is again squeezed. It is then again boiled with a liquid that has come off nearly spent bark, again squeezed, and finally boiled with water. During these four boilings the bark after each squeezing diminishes greatly in bulk and becomes almost pulp, so that it occupies far less room in a pan at the third boiling to what it did at the first. The order in which the several liquids used in extraction are employed depends on the qualities of bark under manufacture; but it is so arranged as to obtain finally a liquid containing as much alkaloid as possible in solution, and also that, as far as possible, the bark should be exhausted of alkaloid. Finally, there arrives a point when the amount of alkaloid in the bark has become so small as not to repay the expense of further extraction. The bark then is dried in the sun and used as fuel.

* This is the amount of acid employed for *trunk* bark, for *prunings* but one per cent. or even less is ordinarily used.

18. The liquid, which if the foregoing be judiciously managed should be intensely bitter and strong, is evaporated to about one-sixth of its bulk, transferred to a tub, and allowed to cool. It is then decomposed by neutralization with milk of lime which precipitates the alkaloids, decomposing the quino-tannates and sulphates with formation of insoluble lime salts. A slight excess of lime is always added. After standing for a day the precipitate is separated by filtration, squeezed, dried, and powdered in a common ragi mill. The liquid which contains abundance of calcic quinate in solution is thrown away.

Precipitation of extracts with lime.

19. As first conducted, the evaporation mentioned in the foregoing paragraph was omitted, the precipitation being at once performed in the original liquid. But, as alkaloid is unfortunately slightly soluble in lime-water, this proceeding was found to produce considerable waste, and therefore it was found necessary to evaporate in order to reduce this waste to a minimum. In India lime must necessarily be the precipitant as it is by far the cheapest of all the alkaline bases. I have tried both English caustic soda and Indian soudoo as precipitants of the alkaloid, but for many reasons do not now employ them.

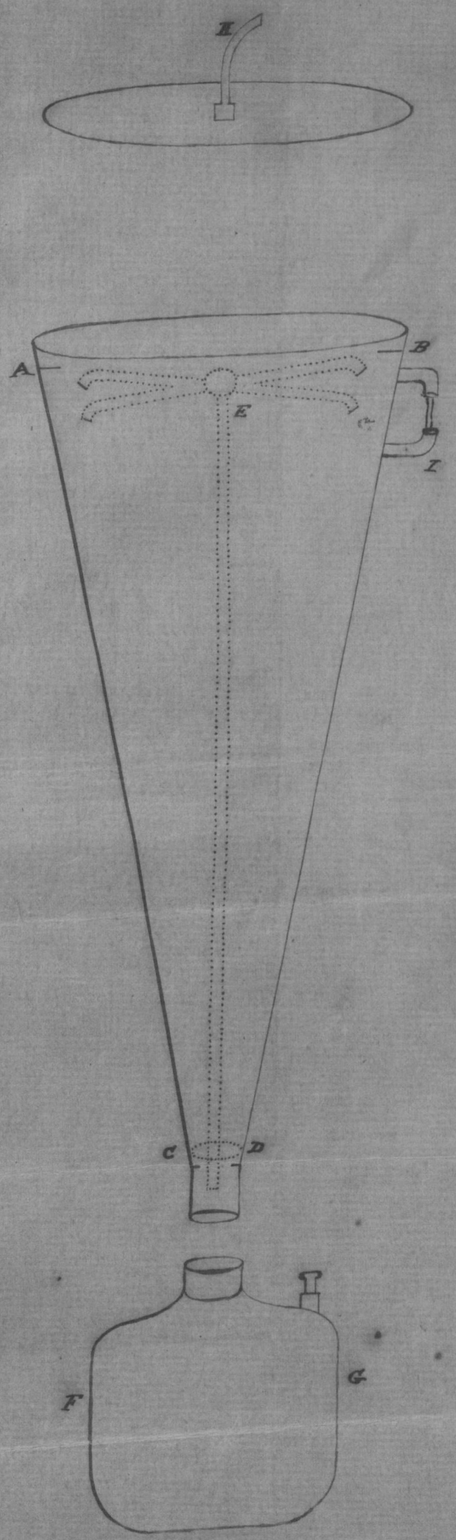
Evaporation was at first dispensed with. Necessity for the use of lime.

20. **The powdered lime precipitate is then packed** in the apparatus, of which a drawing is given, ABCD, being a large cone of sheet-iron, through the centre of which passes an upright tube the upper end of which terminates in a cross-piece with four openings. The lower end of the tube is also open and supplied on a flat perforated circular disk (CD) made of sheet-iron. This allows it to rest in the cone. Below, and tightly fitting to the lower part of the cone, is an under-copper vessel (FG). The cone is supported by chains and above, it is placed in connection with the lower end of a simple worm-tub (not shown in the drawing) by means of a tube (H). The powdered lime precipitate is filled in the cone till immediately under the cross tube (E). The upper lid of cone is fitted on and alcohol poured on till, by passing through the precipitate, the lower vessel becomes about a-third full. The spirit is then saturated with alkaloid, which is neutralized with care by diluted sulphuric acid of which the strength is known. Then the upper lid of the cone is put into connection with the upper condenser by the tube E and a fire is lighted below. The spirit boiling in FG rises in vapour through the inner tube and passes out at the four openings of the cross-piece. It here generally condenses to a liquid, but if not it passes into the copper condenser, where it, of course, condenses, so that by a judicious arrangement of the fire a layer of liquid is kept on the surface of the precipitate. A gauge (BI) allows this to be seen from the outside. If the fire is, however, kept too fierce no harm can ensue, since, if the layer of liquid rises in consequence higher than the percolation through the precipitate removes it, it simply passes down through the centre tube into the lower vessel. Hence the apparatus is self-acting and the cooly work-people have no connection with the alcohol, which is all inside the apparatus. A small amount of alcohol by constant circulation through the apparatus thus completely dissolves the whole of the Cinchona bases without any waste of spirit or alkaloid. Every two days the alkaloid is neutralized with dilute acid. If this be done with moderate care there is no chance of the copper under-vessel being in the least attacked, but if very carelessly done a mere trace of oxide of copper is dissolved. This, however, rarely occurs; but, if it does, it is readily remedied subsequently.

Proceedings employed to exhaust with alcohol.

21. The fire is thus kept up until the whole of the alkaloid is dissolved and passes into the lower vessel. This state of things is known by the alkalinity of the liquid in the lower vessel not increasing. But to make sure the spirit dropping from the cone is usually tested when the process draws near its end. When finished the exhausted precipitate does not contain a trace of alkaloid, all being in the lower vessel. The lower vessel is then removed and the alcohol separated by distillation. Water is also poured on the cone, in order to wash out the alcohol with which the precipitate is still moistened, until the latter is quite removed. The alcohol is thus nearly all recovered, and is purified for another operation by distillation. With care waste of spirit practically does not occur, but I have been unable yet to prevent all loss of spirit from the carelessness with which every operation in this country appears more or less attended. The loss, however, has not exceeded six per cent., and has fallen frequently much below this.

Recovery and actual waste of alcohol.



22. The alkaloid sulphates in the lower vessel is suddenly diluted with about ten times its bulk of cold water. This separates a considerable amount of black resin. Since the contamination of copper occurred in Bengal in the alkaloid I have always as a precaution added a small amount of a dilute acidulated solution of sodic sulphide to the liquid. This completely removes copper if it be present, though with very moderate care it is completely unnecessary. The solution is still, however, coloured with impurities, to remove which a small amount of alkaloid is precipitated by the addition of dilute caustic soda, which carries down with it the colouring matters. The whole is then filtered through a cloth bag, and the alkaloid in the filtrate is precipitated by caustic soda, separated by filtration, squeezed, dried, and powdered. It is then "Amorphous quinine." Before it leaves the manufactory as a precautionary measure it is always tested for copper.

Purification and precipitation of alkaloid.

23. Formerly, from the ashes of the fuel employed, caustic potash was prepared to use as precipitant instead of soda. But lately so small an amount of potash has occurred in the ashes that this has been discontinued. If the Cinchona wood from coppiced trees was employed as fuel this might be again resumed and thus a further saving effected.

Potash should be obtained from ashes of fuel.

24. Sulphuric acid has been used in preference to hydrochloric acid mainly because it is the cheaper acid. While the cost is nearly the same the effective work produced by the sulphuric acid is nearly double that of hydrochloric acid for equal weights. It has also some better qualities for transit through the tropics. The use of sulphuric acid has also some chemical advantages which I need not further particularize. With red bark there is unfortunately no fear of the sudden crystallization of quinine sulphate on the dilution mentioned in paragraph 22 as there would be with crown bark.

Why sulphuric acid is preferred for extraction of bark.

25. The alkaloid which is carried down in connection with the precipitated resin, and in the purification by fractional precipitation, is, of course, from time to time obtained free from impurities by the obvious methods of drying and digestion with dilute acids, etc. Thus obtained it is generally very pure and colourless.

Alkaloid contained in the resin is not wasted.

26. Throughout the whole course of manufacture simplicity of arrangement has been carried out as far as possible. The reasons for this are—

Simple apparatus throughout have been preferred.

1*st.*—That certain labour-saving appliances which are used in England would here be a source of considerable expense and are obtainable with great difficulty and delay. Until alkaloid manufacture in South India has proved itself a permanent success I have, therefore, felt it wiser to refrain from all dispensable expenditure for apparatus for which simple substitutes could be provided.

2*nd.*—That the simpler the apparatus the more readily are they repaired, when necessary, in India.

3*rd.*—The intelligence of Canarese coolies on the Nilgiris is fully exercised by the simplest proceedings of manufacture, therefore any increase in their apparent complexity has to be made with a risk of loss and injury to the apparatus.

27. The whole of the trunk bark supplied to the manufactory during t e year 1872-73 has been obtained under the mossing system which has virtually been adopted by the Madras Government. This method of cropping bark has the disadvantage of only permitting the supply of good bark to be furnished during the two months at the beginning and the two months that end the monsoon. Hence during that time the pressure of work is very considerable while during the remainder of the year it is very light, so that I have been glad at the latter period to work with very inferior prunings, for the purpose of keeping the establishment employed, although I knew such bark could not be worked with profit.

Trunk bark is only supplied at beginning and end of monsoon.

28. Though I am aware the refraining from coppicing cannot be permanent, it has had a further result for which at the commencement of manufacture I was unprepared. At that time I believed the supply of fuel from the plantation would be unlimited from the coppicing of the trees. But up to the present time as coppicing has not been practically carried out no fuel has been obtained from the Cinchonas. The fuel hitherto employed has been furnished by the trunks and branches of trees that once formed part of the original Shola on whose site the plantations were formed, and now lie among the Cinchona trees. In a short time this source of fuel will be exhausted, and is now a more costly fuel than Cinchona-wood would be.

Plantations have not supplied fuel for manufactory.

29. I will now state the results that have been obtained in the year 1872-73 in the manufacture of Cinchona alkaloid and the actual cost of preparing the same.

30. I should state that a more recent examination of returns has shown that the 3,613 lbs. of *Officinalis* prunings mentioned in my annual report (paragraph 2, G. O., No. 714, of the 9th July 1873), had previously been included in the 46,440 lbs. stated as red bark prunings, and thus were mentioned twice over. The correction will, therefore, reduce the total amount of bark supplied to the manufactory by 3,613 lbs. I correct this for the sake of accuracy, though the difference to the amount of alkaloid due is but 4½ lbs.

A correction of the amount of bark supplied.

31. I have the honour to give in Appendix to this report a statement of the actual expenditure subsequent to last official year that has been necessary to work up the unfinished product of that year, which was in the state described in paragraph 18, or lime precipitate. The pay of the Superintendent is not included as during the time he has been mainly occupied in extracting fresh bark, and during the early part of 1872-73, he might have been similarly occupied in working up the lime precipitate of the previous working season had any remained. Every real expense has, however, been charged that has been required for the preparation of the alkaloid fit for sending to the Medical Stores, Madras. No repairs of apparatus have been required. All the resin, fractional precipitates, etc., have had the alkaloid separated in order to ascertain the true result of the work of 1872-73, so that nothing is assumed on estimate.

Superintendent's pay not charged in subsequent expenses.

32. From the lime precipitate obtained during the last official year that remained for exhaustion with alcohol 130 lbs. and 11 oz. of "Amorphous quinine" have been obtained. This is less than I at first expected and stated in my annual report. My estimate was founded on the amount of lime precipitate that required treatment, the yield of which was fairly assumed to be the same as that worked up in the year. I therefore hoped that a quantity of alkaloid not very far below the theoretical amount would be obtained. I now find that lime precipitate from poor prunings, like those worked up during the latter part of last year, contains far less alkaloid than that obtained from good bark. The extra expenditure necessary for obtaining this 130 lbs. and 11 oz. is, however, but small, being but 1 Anna and 8 Pies per ounce.

Amount of Amorphous quinine obtained from lime precipitate.

33. In order to determine the true total yield of the barks that were supplied in 1872-73 I have placed in Appendix the results of the many analyses that have constantly been made during the year. These have been performed, as far as possible, on a carefully selected average sample of each kind supplied. The results of these multiplied by the respective weights of the barks will express closely the total yield of the bark supplied. The total shows that 537·9 lbs. was contained in the whole of the bark. The total weight of alkaloid obtained in manufacture is 345·68 lbs.

Theoretical yield of total bark supplied.

34. It must not be supposed that it is possible in manufacture to obtain the same results as are obtained in analysis, as analytical methods of procedure cannot be carried out on a lagre scale, even if the cost permitted. Whether manufacturers, however, compared the theoretical yield of total alkaloids in the bark worked with the actual amounts they obtain in manufacture I do not know, but there is no record of their having done so. Quinine manufacturers are only specially interested in obtaining all the quinine from the bark, and would have no great care for the other alkaloids, which at the time I left Europe usually accumulated on their hands unsold. It is, therefore, probable that a comparison such as I have made is made for the first time. It is on this account I have been anxious to have it as complete as possible, and hence the delay in the submision of this report.

Analytical results can never be obtained in manufacture.

35. I will indicate the sources of the loss of alkaloid which occur in the manufacture, nearly the whole of which are preventable only at a greatly increased cost of labour and product.

Sources of waste of alkaloid in manufacture.

1*st*.—The not quite complete exhaustion of the bark of alkaloid on first extraction with acidulated water. Usually the bark at the end of the boilings described in paragraph 16 of this report still contains a small amount of alkaloid which another boiling and squeezing would remove. This is not now performed, as the small amount of alkaloid obtained would not repay the cost of the labour, fuel, and subsequent evaporation.

2*nd*.—Spilling and waste of extract, and occasionally of bark itself, by the carelessness and indifference of the coolies. This is not preventable in India.

3*rd*.—Waste of material in grinding the lime precipitate and in final dering of the alkaloid. This may, with care and training, be diminished, but ca: ot entirely be obviated.

4*th*.—The solubility to a small extent of the alkaloid in lime-water. At the beginning of the year 1872-73 loss from this source occurred. It has since, as I have before mentioned, been prevented by the evaporation of the liquid extract of bark down to a small bulk, before the precipitation with milk of lime is performed. I cannot fairly estimate the amount of waste that has occurred from this source, but believe it will not have exceeded 20 lbs. of alkaloid.

36. As a measure of precaution I have repeatedly tested whether the lime precipitate is completely exhausted of alkaloid by the alcohol before throwing it away, and have always found that no alkaloid is wasted by imperfect exhaustion, as might otherwise be naturally supposed.

37. I will now state the total cost of manufacturing the alkaloid. In Appendix I give a statement of all the expenditure connected with the works for the working up of the bark supplied during the year 1872-73. This excludes the cost of apparatus and repairs, the latter expense being, however, but small. It also excludes my own pay, as manufacturing work can go on, after once established under the Superintendent, without the necessity of a Chemist's intervention. During the year my time has been more occupied with other duties than with the alkaloid works at Neddivuttum, which I visit but weekly.

Quinologist's pay excluded from manufactory expenses.

38. The total expenses, therefore, have been Rs. 2,823-11-9, and 345 lbs. and 11 oz. of Amorphous quinine have been obtained. This shows that the expense of preparing each ounce has been 8 Annas and 2 Pies. This does not, of course, include the cost of the bark, but is that of manufacture only. This cost is within my original estimate (letter attached to G. O., No. 249, of the 7th February 1871). This estimate was framed on the assumption that 800 lbs. were manufactured and that the bark worked had a mean yield of four per cent. of alkaloid when dry. The bark supplied in 1872-73 has had a mean percentage of scarcely three on account of the large quantity of nearly worthless bark from prunings, supplied during the dry weather, which frequently contained but 0·5 per cent. of alkaloid when dry. The results of manufacture on the score of cost appear, therefore, satisfactory.

Cost of manufacturing per ounce of alkaloid.

39. G. O., No. 714, of the 9th July 1873 does me the honour of requesting my matured opinion on the expediency of manufacturing any febrifuge in this country. Before expressing this I beg respectfully to make some remarks on paragraph 3 of the same Government Order.

Requests leave to discuss Government Order.

40. In this paragraph it is accurately stated that 1*s*. per pound may be taken as the value of (green) red bark, basing this estimate on the despatch from His Grace the Secretary of State, recorded in G. O., No. 1,429, of the 16th October 1872, in which it is stated that (commercially dry) red bark sold at from 2*s*. 1*d*. to 3*s*. 1*d*. per pound in England. This, of course, would be the value of the dried and packed bark after conveyance home. But if the manufactory be charged the English price for bark grown on the spot in India, it will follow that the febrifuge

Value of bark attributed.

must be produced at something near the English price of quinine sulphate, or, as the Government Order states, the cost of the alkaloid will be Rs. 3-9-6 per ounce. The present English price of quinine sulphate is 9*s*. 6*d*. per ounce, or roughly Rs. 4-12-0. If the Madras Government, therefore, desire the profit on the sale of Cinchona bark at the present English prices, it must not expect at the same time a febrifuge for Indian use at the price of Rupee 1 per ounce.

41. I will again state the reasons that to me appear convincing why the present English price of red bark cannot continue. This bark, whether renewed under moss or not, is nearly unfitted for the manufacture of quinine as it contains so little, and that little is difficult to obtain as crystallized sulphate. It is used for the manufacture of tincture and other pharmaceutical preparations. I am informed on good authority that annually 1,00,000 lbs. of Cinchona bark are used for these purposes in England. Without counting the Government plantations the private plantations of the Nilgiris contain nearly a million and a half of trees of *C. Succirubra*, which will in a short time supply at least fifteen times that amount annually. To this must be added the yield of the private plantations in Bengal and in other parts of the world. I cannot but conclude that with this enormous supply the price of red bark must very shortly fall in the English market till it only just pays for the cultivation and export. It is quite possible that the employment of Cinchonidine and Cinchonine in medicine may hereafter give red bark a certain manufacturer's value, but much time must elapse first. At the present time the qualities of Indian red bark are scarcely known in England, but they will shortly become so. The foregoing are, therefore, the reasons, as I before stated, on which my choice of the form of febrifuge and the bark from which it is to be obtained are mainly founded.

Reasons why the price of red bark will decline.

42. But for a short time to come the value of the bark attributed to it by Government will doubtless be the main influence in their estimates of the expediency of manufacture in South India, In all papers previous to G. O., No. 714, of the 9th July, it appears to be implied that the actual cost price of the bark on the plantations should be the element of cost in that of the alkaloid. If the present prices obtained by the sale of bark in England be debited to the alkaloid manufactory for its raw material, it is quite clear that a cheap febrifuge will be impossible, and I could have positively stated this before coming to India. The profits of sale and cheapness of febrifuge cannot co-exist. If all the bark whose alkaloids will finally be used in India be exported, the additional and apparently unnecessary labour of drying, packing, transport, and sale of bark will be taken, and the advantage of the control of manufacture will be sacrificed which permits a more abundantly occurring form of febrifuge to be used in India. It is for His Excellency the Governor in Council to determine whether the profit of sale of red bark in England or cheapness of febrifuge for use in India be the end to be obtained.

English prices of bark incompatible with cheapness of febrifuge.

43. My matured opinion, therefore, does not differ from the one I formerly expressed concerning alkaloid manufacture in India (letter recorded in G. O.,

Manufacture to some extent must continue.

No. 219, of the 7th February 1871). But, under any circumstances, as long as Government export red bark, advantage will be found in having some means of obtaining the alkaloid contained in the bark of prunings and waste bark that is not worth carriage to England, which must always occur on the plantations in considerable quantities. Therefore, if my opinion is not held by Government, the small manufactory now established in action will still have work.

Suggests further medical report on Amorphous quinine.

44. I would suggest that, if any doubt is felt of the medicinal efficacy of Amorphous quinine after the original report of the Inspector-General of Hospitals, recorded in G. O., No. 29, of the 11th January 1871, that a further expression of the opinion of the Medical authorities on the same should be called for by Government.

APPENDIX.

Cost of Alkaloid manufacture from the Cinchona Bark supplied during the year 1872-73.

Description of Charges.	Cost.		
In year 1872-73.	RS.	A.	P.
Pay of Superintendent and Coolies ...	1,744	8	0
Extra labour	62	15	6
Contingent expenses	102	11	6
Fuel	82	0	0
Lime	72	8	0
Carriage of Alcohol and Lime	33	10	9
Cost of Alcohol used	90	0	0
,, of Acid sent out by India Office ...	407	0	0
,, of Soda	19	13	10
Subsequent Expenses.			
Cost of collecting Fuel	37	3	0
Labour	56	8	6
Soda	9	13	6
Alcohol	84	0	8
Acid	6	5	0
Oil	11	9	4
Cost of powdering the Alkaloid	3	0	0
Total...	2,823	11	9

		Bark sent green as analyzed.	Per cent. Dry.	Weight of Dry Bark.	Per cent. of Alkaloid.	Weight of Alkaloid.
Bark of *C. Succirubra.*	1st April to 20th May 1872.					
	Neddivuttum, Trunk	943	30	282	4·1	15·5
	Do. Prunings	10	.....	.....	.....	.....
	20th May to 18th June.					
	Neddivuttum, Trunk	2,118	28	612	7·1	43·4
	18th June to 3rd July.					
	Neddivuttum, Trunk	3,140	29	910	.....	38·2
	3rd July to 18th July.					
	Neddivuttum, Trunk	2,184	29	633	5·1	32·2

		Bark sent green as analized.	Per cent. Dry.	Weight of Dry Bark.	Per cent. of Alkaloid.	Weight of Alkaloid.
Bark of *C. Succirubra.*	18th July to 7th October.					
	Neddivuttum, Trunk*	7,767	30	2,330	4·8	111·8
	7th October to 16th October.					
	Neddivuttum, Trunk	7,357	26·8	1,971	4·3	84·7
	Do. Prunings	814	25	203	1·7	3·4
	16th October to 24th October.					
	Neddivuttum, Trunk	2,679	25·8	691	3·5	24·1
	Do. Prunings	533	25	133	2·6	3·4
	24th October to 4th November.					
	Neddivuttum, Trunk	3,860	27·7	1,071	4·3	46·0
	Do. Prunings	4,749	24	1,139	2·6	29·6
	Pykara, Trunk	958	27	258	5·0	12·9
	Do. Prunings	1,480	25	370	1·6	5·9
	4th November to 21st November.					
	2 Neddivuttum, Trunk	24	28	6	5·0	0·3
	Pykara, do.	750	27	202	5·2	10·5
	Do. Prunings	1,486	25	317	1·5	5·5
	21st November to 13th December.					
	Neddivuttum, Trunk	22	27	6	4·0	0·2
	Do. Prunings	66	25	16	2·2	3·5
	Pykara, Trunk	1,419	27	383	4·0	15·3
	Do. Prunings	4,875	25	1,219	1·1	13·4
	13th December to 9th January 1873.					
	Neddivuttum, Prunings	1,251	25	312	1·8	5·6
	Pykara, do.	7,100	24	1,700	0·5	8·5
	9th January to 10th January 1873.					
	Neddivuttum, Prunings	135	25	148	0·7	1·0
	Pykara, do.	450				
	10th January to 27th January.					
	Neddivuttum, Prunings	1,671	24	1,636	0·5	8·1
	Pykara, do.	5,147				
	27th January to 24th February.					
	Neddivuttum, Prunings	†7,603	25	1,900	0·6	11·4
	Pykara, do.					
	24th February to 3rd March.					
	Pykara, Prunings	1,890	25	472	0·5	2·3
	3rd March to 18th March.					
	Neddivettum, Prunings	1,147	Not worked.			
	Pykara, do.	2,520				
	Prunings of *C. Calisaya*	450	27	121	1·0	1·2
	Do. of *C. officinalis*	3,613	Nearly worthless.			
	Total...	80,281	.....	19,041	79·5	537·9

* 600 lbs. from decayed trees.

† 3,613 lbs. of prunings of *C. officinalis* have here been deducted.

Ootacamund
1st December 1873.

From Mr J. Broughton
Government Zoologist
Ootacamund

To D. F. Carmichael Esqr
Secretary to Government
Revenue Department
Fort Saint George

Sir,

I have the honour to enclose a report on the manufacture of alkaloid from the Government Cinchona Plantations at Neddivattum, and beg permission to be allowed to correct the proofs of the same before publication.

2. I further request that I may be allowed to have four copies of the same.

I have the honor to be
Sir,
Your most obed. Servant
John Broughton
Govt Zoologist

Revenue Department.

No. 408

PROCEEDINGS of the MADRAS GOVERNMENT.

Under date the 1st April 1874.

READ the following letters from the Government Quinologist

Submitting report on Alkaloid manufacture	H. E.	1 December 1873
Submitting a Statement of the total expenditure connected with the Alkaloid manufactory, the quantity of bark consumed, & the out-turn of "Amorphous quinine" since the year 1869.	— 4 —	16 March 1874.

Ordered to lie over pending the receipt of the report from the Surgeon General Indian Medical Department

to

to G.O. dated 2nd March
1874 No. 286.

Copy of the fore=
=going will be communica=
=ted to the Officers noted
in the margin.

Surgeon General Indian
Medical Dept.
Sanitary Commissioner
Commissioner Nilgiris
Government Entomologist

50/6

6 To the Surgeon Genl Indian Medl Dept. Ors 15 Apl/74
6 " Sanitary Commr — " —
3 " Commr Nilgiris " —
1 " Govt Entomologist —

No 4.

Alkaloid Secretary

Enc 2s

c 27 March/74. R36.

837

Revenue Department.

Memo for Orders on C. N.° 3881.

From the Govt Quinologist.
Submitting report, and requesting permission to correct proofs &c.

N.E. 1 Dec/73

In July last, the Government, when reviewing the Annual report of the Government Quinologist, calculated that the outturn of Amorphous quinine for 1872-73 would be 500 lbs at a cost of Rs 3. 9. 6 per oz, viz:

Estimated cost of production of 500 lbs		Rs 3270
Share of cost of Apparatus & repairs	"	1730
Cost of bark (estimated at English prices)	"	28,750

As the Quinologist's original estimate of the cost of manufacturing this febrifuge was 1 rupee per oz, he was asked, when reporting the actuals of the year, to give his matured opinion as to the propriety of attempting the

⊙ There is nothing on Record showing how this amount was arrived at Sec.

⊙ See his letter dt. 8th Aug.: 73 in P.O. 7th Feb.: 74 N. 249.

the manufacture of any febrifuge in this country.

II. Mr. Broughton now reports the actual outturn to have been 345.68 lbs made at a cost of Rs 2823-11-9, or 8 as. 2 pie per oz - This leaves a sufficient margin for the two remaining items of his original estimate viz (1) cost of bark at 4 as per oz on the spot, —— (2) interest on plant at 5 per cent, and he therefore would continue the manufacture. He points out that his original estimate was for a larger quantity, viz 800 lbs, which could be made at less cost relatively, and was further based on the presumption that the bark supplied would afford a mean yield of 4 per cent of alkaloid when dry, whereas that actually used in 1872-73, being largely composed of worthless prunings taken in the dry weather, "had a mean

per

* Note. His own way is excluded, as once started, the manufacture does not require a chemist's intervention - (See para 37).

* He says there will always be work for the present small manufactory in using up bark not worth exporting (See para 43) of Let.

See para 40-42.

per centage of scarcely three."

III. Lastly he takes exception to the cost of the bark supplied being estimated at English prices - These he believes will decline, but, any way, if they "be debited to the alkaloid manufactory for its raw material, it is quite clear that a cheap febrifuge will be impossible," as it will "be produced at something near the English price of Quinine Sulphate."

IV. The following points are also touched on, or discussed, by Mr. Broughton in connection with this question.

(1) The efficacy of the preparation "Amorphous Quinine" now manufactured:

As the Government stated that Sulphate of quinine "is believed to be a superior article," he suggests a reference to the Medical authorities -

(2) The mode of manufacture:

This

* Note - So named because "it consists of the alkaloids (mixed as they naturally occur in the plant) precipitated from solution in an insoluble [illegible] crystallized state" (para 4 of Mr. Broughton's letter 31 August 1870 in G.O 7 February 1871 No 249)

c 27 March/74 R30-

This is simple, economical, and (if carefully superintended) safe; but it is to be noted that whereas the bark used actually yielded 345.68 lbs, it should, by Mr. Broughton's own analysis of samples, have given 537.9 lbs. This waste Mr. Broughton considers only partly preventable, and that at a greatly increased cost.

(3) The mossing system:

Under this, good bark can only be supplied during 4 months in the year, and the fuel, which the coppicing system would furnish, is lost.

V. It must be borne in mind throughout, that Mr. Broughton's remarks, in support of local manufacture, are limited to the present preparation, and it is submitted that further medical testimony as to its efficacy

pi

See paras 33-34.

c 27 March/74. R30.

is required. It appears to be cheaper than Sulphate of Quinine, but this is of little consequence if larger or more frequent doses are required to effect a cure—

Since the above was written, a Despatch, in which this subject is discussed, has been received from the Secretary of State, and is now put up with a draft order calling both on the Medical authorities and Mr. Broughton, for full information as to the quantity of amorphous quinine made and used, its cost, efficacy &c &c.

Sal.

(This was my experience in the Kistnas, where I distributed large quantities.)

*No. 25 - 16 December 1873.

We can take no action on this Report from the Secretary of State until we get the full information which he is calling for and we receive his further despatch here noticed. From the result of these enquiries it will be evident enough what course we shall take later in respect of the future manufacture of amorphous Quinine.

[illegible]

Theories for Orders
Labour Required

3881/75
8851/73

Revenue Department

C No. 3881.

Government Quinologist.
Dated 1st December 1873.

FOR ORDERS.

The whole question of dear-
ness & cheapness of Quinine de-
pends on the
material used. The cost
of manufacture is much
cheaper than that of Sulphate
of Quinine and the efficacy
of the Drug is little if at all
inferior. But if in making
it we use Extractive both the
total cost must come high-
But it was always to bear in
that for the preparation of the

RE-17 March-R30.
C 16 Jany/74 R 17 March 1874 for 18-R30
C 27 March/74-R30.

simples they could bark could
could be used which it could
not pay to send home. and Mr
Broughton has used much of this.
The correct plan would be Clearly
is to charge for the bark its proper
market value here - if there be
no such criterion, then its value
at home a the deducting possibly
freight &c - he thinks then know
what this new drug really costs us
and this it is desirable that
he should do

The pt. now entered into
this chichona business as a money
speculation - and it is very ques-
tionable that they should compete
with the private individuals in this

c 27 March/54. R30.

this branch of industry -
therefore my self in favor of send-
ing yearly a sufficient Quantity
of the superior descriptions of
bark which yield Genuine sorts
to bring the Indian product into
into the market and to ascertain
the other descriptions to the Manu-
facture of cheap febrifuges for
the non paying classes of
fresh Grains & to be annually
sent of same by thousands - Eco-
nomically this will be cheaper
at the present price of Grains -
& as selling on bark at home
importing Grains & distributing
it at the price of Cinchonas 2:
the difference in cost Mr Broughton
says is about R. a. 1-2 = 3/3 d. per oz. &
the relative febrifuge powers of the two drugs

[illegible] for a
[illegible]ately. He must
[illegible]ep up a Simultaneous
[illegible]nd a Mean Jealousy
[illegible]r time you [illegible]come.
[illegible] & many Soldiers
[illegible]ble Enemies unblood.

He must, I [illegible]ume, Mean
the Concurrence of the Home Pt
& any Permanent L & Vessel
arrangement of this Nature and
Plan, if my Hon[illegible] Colleagues Conduct
can be kept when we let the
Dept called for from the Head
Dept in the prosecution Service
period of the Annual Estimates Reqs.

L. & L.

Lapsed
1783 Mch

C 16 Jany/84. R 17 March. Y Capt S.H.S. Lt Mar.
[illegible]

C 27 March/84. R 30.