Account of a new species of merium, the leaves of which yield indigo ... To which is added, a brief account of ... experiments made ... to throw ... light on the theory of that artificial reproduction. Also descriptions of two other plants, which yield indigo, and of one from Pegu, said to yield a green dye / [William Roxburgh].

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Indigo 44861/P

Roxburgh.

Nerium Indigo.

PAPERS

IN

COLONIES AND TRADE.

In the present state of the Commerce of this Country, when our Enemies are endeavouring to close every Foreign Port against us, it is the Society's wish and endeavour to show the great Advantages and Resources which may be derived from our Colonies, and to give every Encouragement in facilitating their Efforts to furnish Articles which will answer the purpose of those usually derived from Foreign Kingdoms. Supplies from such being generally precarious, and procured at a great Expense to this Country.

In the Year 1786 *Great Britain was almost wholly dependent upon Spain and France for the Indigo made use of in our Manufactures; the Imports of this Article from the East Indies at that period being only £.57,002 in Value.*

By subsequent Encouragements given to its Product and Manufacture in our Colonies in the East Indies, the quantity of Indigo sent to London from thence has annually increased to an immense extent, being in the Year 1809 4,740,926 *lbs. weight, and in Value* £.1,105,678 *sterling; and this Country is now rendered wholly independent of any Foreign Power for the Article.*

The following Account of the Preparation of the Nerium Indigo, communicated by Dr. WILLIAM ROXBURGH, *of Calcutta, will be found interesting to the Public. Two Explanatory Engravings are annexed. Drawings of the several Plants mentioned, also of the Buildings and Apparatus necessary for the Preparation of the Indigo, are preserved in the Society's Repository.*

Account

Account of a new Species of Nerium, the Leaves of which yield Indigo, with an Engraving of the Plant, and Descriptions and Engravings of the necessary Apparatus for manufacturing the Indigo. To which is added, a brief Account of the Result of various Experiments made with a view to throw some Additional Light on the Theory of that Artificial Production. Also Descriptions of two other Plants which yield Indigo, and of one from Pegu, said to yield a Green Dye.

SINCE I wrote my first description of this tree, and of the process for manufacturing the indigo from its leaves *, many circum-

* These were sent to England 1790, addressed to the Honorable the Court of Directors of the East India Company, and since published by A. Dalrymple, Esq. in his Oriental Repertory. A copy of the same paper was sent to a friend in Calcutta, who thought it deserving the attention of the Supreme Government at Bengal, and submitted a Copy of it to the Governor-general and Council, accompanied by the following letter:

To EDWARD HAY, *Esq. Secretary to the Government.*

"SIR,

"Enclosed is an extract of a letter, dated June 8, 1790, from Dr. Roxburgh, of Samulcottah, accompanying a specimen of indigo obtained from the leaves of a tree, a native of the lower regions of the mountainous tract forming the Rajah-mundry frontier. This species of indigo, in the estimation of Messrs. Harris and Haven, promises to be a very valuable acquisition, and its value further enhanced from the consideration of its rising in a sandy or sterile as well as in a rich soil. That from being perennial (like the Sumatra species) and attaining to the stature of a tree, affording a permanent stock and unfailing resource against the devastations to which the culti-

circumstances, arising from innumerable experiments and repeated enquiry, have come to my knowledge respecting

vation of the more common annual different species of indigo (hitherto generally recurred to within the Company's Provinces,) are subject, being from their nature more exposed to failures from an unfavorable spring or disastrous season. From the annexed description of this tree, furnished by Dr. Roxburgh, it appears to be of the Genus Nerium, and will probably be found on our S. W. frontier.

"Of the seeds of this tree received, part have been sent to the collectors of Bhaugulpore and Gyah, and some hundred plants are now raising in the Company's garden, so that we shall be enabled to avail ourselves of this additional resource by a general distribution, during the present season, to the several indigo planters within the provinces, of which public notice may be given (on requisition being made) to take place in the course of the month of August, by which time we shall also be enabled to obtain a comparative estimate of its productive qualities, with the other species now in use.

"Should the avocations of Administration at any time permit them to descend to the examination of the situation and soil of the hilly tract, on which the residence of the collectorship of Hidgellee is situated, as described in the Diary of the tour through part of the tract in the year 1789, submitted on the occasion of an imperfect attempt to examine the maritime productions of that province, it will be perceived that that very uncommonly situated region is particularly adapted to the cultivation of this species of indigo. But I learn from the collector, that the greatest part of this tract (although in extent between twenty and thirty coss) is productive of little or no revenue to the *soi disant* possessor, the Ranny of ————; but I am wandering from the only subject which can entitle me to occupy the attention of the Board. The report of a new species of indigo brought under notice by the discernment and researches of Dr. Roxburgh, and I crave pardon for a digression from the subject into which I have been involuntarily led.

"I have the honor to be,

"&c. &c. &c."

[In consequence the paper was printed in Calcutta by order of Government, together with a very clear and satisfactory account of the method of making indigo from the common indigo plant, *(indigo fera tinctorea,)* as practised at Singatollah, near Malda.]

the

the tree, the process for preparing the indigo, its quality, &c. &c. such as to render a more complete account of it necessary, and which the quality of the indigo fully justifies, the more so, as quantities of the seeds of this tree were sent by me from the Rajah-mundry Circar to various parts of the world since the year 1790.

On St. Helena and the West India islands there is great abundance of soil and situation favorable to the culture of this tree, viz. hills, and the lower regions of mountains where there is little else than rocks, stones, and the most barren soil; such being the soil and situation I have always found it upon. One of the circumstances that have come to my knowledge respecting this tree is, that the natives of Vizagapatam and Ganjam districts, and some parts of the Carnatic, have been long acquainted with the quality of its leaves. Dr. Patrick Russell writes me from England, that among the papers of a most worthy sensible man, (an old college companion of mine,) the late Dr. George Campbell, who was a surgeon in this (the Madras) Establishment, and died of wounds he received in the action between the detachment under Colonel Baillie and Hyder Alley in 1780, there was found an account of the tree, and that the natives made Indigo from its leaves.

These circumstances were totally unknown to me when I first wrote upon the subject, otherwise I would have mentioned them at that time with as much readinese as I do now.

NERIUM.

Linn. Gen. Pl. Ed. Schreb, No. 420.

GEN. CHAR. *Contorted. Corol* funnel-shaped; mouth of the tube with a lacerated crown. *Follicles* two, *Seed* crowned with a coma.

NERIUM *tinctorium, Roxb.*

Arboreous, leaves opposite, short-petoiled, oblong, entire, smooth. Panicles terminal. Follicles pendulous, long, slender, united at the apex.—Anthers naked.

Thsil-ankaloo, of the Telingas.

Nerium indicum, siliquis angustis, &c. *Burm. Zeyl.* p. 167. t. 77.

An elegant middle-sized tree, agreeing perfectly in its botanical character with the Genus Nerium of the Linnean sexual system, and from the quality of its leaves may very properly be called *Nerium tinctorium,* which may be rendered dyers' rose-bay, for to me it appears a new species: it comes nearest to Nerium antidysentericum, *Linn. Sp. Pl. Ed. Willd.* 1 *p.* 1236, the tree which yields the Conessi-bark of our Materia Medica, Codaga-pala of the Hortus Malabaricus, *p.* 85, *t.* 47, Pala-cadija of the Telingas. They are both natives of the lower region of those mountains which bound the Rajah-mundry Circar on the north side, and are so much alike in most respects, the Nectarium excepted, that without a tolerable knowledge of both, the one may be mistaken for the other; and it is probable the bark of this new Nerium may have been gathered and sold for Conessi-bark, to which may be attributed the disrepute that has fallen upon Conessi bark in Europe; for with the natives in these

these parts of India, it is deemed a specific in most complaints of the bowels, and I am inclined to think that it deserves a better name than it has hitherto acquired among Europeans.

DESCRIPTION.

Trunk—erect, short; in large old trees from one and a half to two feet in diameter, but when of that size it is generally full of large rotten cavities. *Branches*—numerous, irregularly disposed in every direction, and bent in various ways. *Branchlets*—opposite, round, smooth, and green; general height of full-grown trees from twenty to thirty feet. *Bark*—of the old wood scabrous, of the young pretty smooth and ash-coloured. *Wood*—white, close grained, very beautiful, approaching the colour and appearance of ivory. The natives employ it for a variety of uses, where a beautiful, light, close-grained wood is wanted. It is strong, and would answer well for furniture was it not apt to acquire a blueish tinge towards the centre. They (the Telingas) say, that if the bark of the tree is burnt off, by lighting a fire round it when first felled, that the wood will ever retain its whiteness and beauty.

Leaves—numerous, opposite, short-petoiled, oblong, pointed, pretty smooth, entire, pale green; when full-grown from six to ten inches long, and from three to four broad.

Stipules—none.

Flowers—about an inch and half in diameter, when fully expanded perfectly white, fragrant, disposed on lax, globular panicles at the extremities of the branchlets.

Bractes—a small oval one below each subdivision of the panicle.

Calyx—one-leaved, cup-shaped. *Border*—divided into five equal semiorbicular permanent segments.

Corol—one-petalled. *Tube*—short, somewhat gibbous.

Border—large, divided into five oblique linear-oblong spreading segments.

Nectary—many, ramous, white filaments crown the mouth of the tube of the corol.

Filaments—five, very short, rigid, inserted on the mouth of the tube just within the nectary.

Anthers—arrow-shaped, rigid, united to one another laterally, forming a very firm conical cover for the stigma; their lower parts are inwardly covered with fine white hairs.

Germs—two, seemingly united. *Style*—the length of the tube of the corol. *Stigma*—double, covered with transparent gluten, by which it adheres to the inside of the anthers.

Pericarp—two, very long, slender, pendulous follicles, united at both ends: singly they are from twelve to twenty inches long, and about as thick as a common pencil, consisting of one valve, which opens lengthwise on the inside.

Seeds—numerous, long, slender, crowned with a downy tuft, or coma, like the seeds of the common thistle. This tree and a variety of it with leaves considerably longer and narrower, and somewhat downy, which also yield Indigo, but of an inferior quality and less in proportion, are natives of the hills and lower regions of the mountains, directly north from Coringa, in the Rajah-mundry Circar, and delight most in the south, or sunny side of these hills and mountains. It (meaning the variety figured and described, which yields the best indigo,) also grows in simi-

lar

lar places in other parts of the Circars, and in the Carnatic, being an extent of above one thousand miles in length, and of breadth uncertain ; it contains a mild milky juice, chiefly in the tender branches and young leaves, which flows out on being wounded. Near inhabited places it is so often cut for fuel, that in such situations it is almost ever found in the state of a very small tree or large bush. It is in uninhabited parts, or where well protected, that we find it becomes a tree of any size.

But to make the trees yield a large supply of the best leaves for making Indigo, it is necessary to keep them low, as found in the vicinity of the habitations of the natives, or in the state the mulberry plantations, for feeding silk-worms, are kept ; with many shoots issuing from the out-stumps. These in one year acquire various heights, of from one to ten feet, according to the nature of the soil, &c. and are thick in proportion.

The leaves drop about the beginning, or during the cold season. In March and beginning of April, they begin to make their appearance, and soon after them the flowers. By the end of April, those that began first to be unfolded, will have attained their full size:—This is the proper time to begin to gather them for making Indigo. About the same time it ceases flowering, and many of the seed-vessels are fully formed ; but the seeds are not ripe till January or February.

The color which the leaves acquired in drying for my hortus siccus, particularly if they happened to be bruised, first induced me to suppose them to be possessed of colouring matter, which numerous experiments and much enquiry have fully confirmed.

Apparatus for Manufacturing the Nerium Indigo.

The quality of the leaves of this tree differ most essentially from those of the common Indigo plant, in not yielding their color to cold water. Every method has been tried that could be thought of, and with various kinds of water, viz. rain-water, soft-water from the well, river-water, and with various kinds of hard water, but all without any good effect; for with cold water I never could procure any other than a very small proportion of a hard, black, flinty substance, which does not deserve the name of Indigo, burning with much difficulty and with a white smoke, into dark colored ashes; whereas that made with hot water, burns readily with a most beautiful, deep, violet-colored smoke, and a strong peculiar smell, into fine white ashes.

Not being able thus to succeed, after a great variety of experiments, conducted in various ways, and at different periods during three years, I conclude that it will be only loss of time to attempt it longer; some other person may be more fortunate; but I have at all times found that they give out their colour most readily to hot water; it therefore becomes necessary for those who intend to carry on this manufacture on a large scale, to have works differing very much from those by which the common Indigo is generally made.

The most essential part of the business consists in applying a sufficiency of fire, at the least expense;—In general I found the price of the fuel was nearly equal to every other charge. I will describe what seems to me to be the best; yet I have no doubt that others, better acquainted with the method of applying fire to the greatest advantage, will soon contrive a better, and on this, in a great measure, will the success of this new manufacture depend; I must, therefore,

beg

beg leave to recommend all possible attention to this point, which I have the more reason to do; because, by this scalding process, I have always, on a small scale, made from the common Indigo plant, better Indigo than I could by fermentation, in one-fourth of the time, and what is also of much importance, without the smallest degree of that pernicious effluvia, which attends the manufacturing of Indigo by fermentation. The twigs and leaves of the common Indigo plant themselves, after being well dried, make a fierce fire, and will in general nearly suffice to carry on the work without any great quantity of additional fuel. The Nerium works have not this advantage, the leaves only being scalded there.

In my first experiments, in 1789 and 1790, I used the common earthen pots of the country to scald the leaves in; but for many obvious reasons, large copper vessels are infinitely superior. They may easily be made of any size of sheathing copper, rivetted together and soldered. I conceive that ten or twelve feet, from the fore part, where the scupper is fixed to the back part, is as much as one fire can well act upon; their extent the other way must depend on the distance they are to be carried, and mode of conveyance to the place where they are to be used. I should suppose five or six feet to be sufficient; if more, it will be very troublesome to move them without injury. Their depth ought not, I conceive, to be more than two feet, in order to avoid overscalding the leaves near the bottom, before those near the surface are sufficiently scalded. Round the edges, on the inside, must be nailed a frame of wood, to support them; on the middle of the forepart, close to the bottom, there must be a scupper of length sufficient to pass through the wall, into a channel, which may be constructed of brick and lime to carry the liquor into the agitation cistern. These

scuppers

scuppers may be stopped with wooden spiggots, or brass cocks; the latter would be more convenient. Any number may be arranged side by side, and if made to communicate with each other near their bottoms it will be convenient, as the water when filling them running in at one place, passes equally into all, without farther trouble; and the sides of the vessels touching each other, do not then require support. Whereas their outsides must be supported by a wall, which must have vent-holes for the smoke, and to give a free circulation to the air in different places to make the fire burn. These vessels must be placed upon strong square bars of iron, at about a foot asunder—their ends supported by the wall, which is to support the outsides of the vessels, and their middle, by small pillars. The great weight of the vessels when filled, requires that this part of the work should be substantial, and the more so, if the vessels are made of sheathing copper. These bars of iron must be placed high enough to give room for the fire under the vessels to act with the greatest force. One fire to each will be found sufficient, and for that, one opening on the side from whence the most prevailing winds blow, must be left for feeding the fire, and removing the ashes. These arches, or openings for the fires will, according to my plan, come immediately under the channel for conveying the colored liquor from the scalding vessels to the agitation vat. Grates, for the fires, would be expensive; they may be made on the floor, a little raised above the level of the adjacent ground, (suppose the works in the open field), and with a small ascent from the fore to the back part, which makes the fire burn better.

The agitation vat may be built of brick and lime, as usual in common fermented Indigo works, never more than three feet in depth, but broad in proportion to the number and size of the scalding vessels employed. Six of them, for example,

example, of the size afore-mentioned, will require the agitation cistern to be about twenty feet square, and three feet deep. In the sequel, it will appear that the blue color of Indigo is derived from the air. It is, therefore, necessary to make the agitation vat, or cistern, very broad, and never deep; eighteen or twenty inches in depth is as much as it ever should be. The other, sixteen or eighteen inches above the liquor, may be called the border, and will not require to be so strong, as it is only to prevent the liquor from splashing over during the agitation.

On the edge of the agitation vat may be placed, or built, a small cistern, perhaps five feet square, to make and hold the lime-water; if this is made to exclude the air entirely, so much the better;—for the action of the air on lime-water soon weakens it so much as to render it of little use; this is an essential point, and ought to be attended to. The principles upon which lime-water is decomposed by exposure to the open air, were first explained by the immortal Dr. Black, and are now too well known to require any explanation from me.

The scupper from this lime-water cistern, must be considerably above its bottom, to give proper room for the undissolved lime to settle in. A shade ought to be built over the scalding vessels to shield the labourers from the intense heat of the sun, but not over the agitation vat; for I have never found rain to do it any harm, and the more it is exposed to the light, open air, and wind, the better. It would be well to keep the surface of the liquor gently agitated by the wind during the time the fecula is precipitating, for it prevents the copper, or violet scum, from forming, which should not be allowed, as it in a great measure prevents that free absorption of the coloring principle, which is derived from the atmosphere, and probably assisted by the contact

of

of light, and not from the plant itself. It is only the base of the commodity which the leaves yield. It is also necessary that the works be erected in a place, where no dust can be raised by the wind; such places are common amongst jungles, &c. where this bush generally grows.

Another small cistern, or receptacle for receiving the fecula (blue precipitate) drawn off, will be very convenient. There it settles to the bottom, when still much of the parent liquor may be drawn off by scuppers, which renders the draining in the bags, or on the table, much less tedious. The bottom of this cistern ought to sink towards the centre, where a small excavation should be constructed for the purpose of taking up the last of the fecula with more ease, and for sand, and other heavy impurities to settle in. Over this small cistern the draining bags may be hung, till the liquor runs clear from them.

Method of Manufacturing the Nerium Indigo.

The leaves in these parts of India, as I have already observed, begin to be fit for making Indigo in the month of April, and in May and June, * I have found them to yield a better colour than in any other month. About the end of August the growth of the plant begins to draw to a close for the season, the leaves acquiring a yellowish rusty colour, soon fall off, without being succeeded by others, or in a trifling

* The hottest time of the year. In the shade the thermometer, during the heat of the day is generally above one hundred, often from one hundred and ten to one hundred and fifteen, and exposed to the sun (nearly perpendicular). On the rocky barren soil, where these bushes grow, it rises between one hundred and forty and one hundred and fifty, an astonishing heat for vegetables to flourish in!

degree,

View of the Nerium Indigo Works, as practised at Hindostane.

Fig. 1.

Fig. 2.

Drawn by J. Farey Junr.

Engraved by S. Porter.

degree, till next season, so that here with the plants in a wild state (which is the state I always allude to in these observations) I can only reckon the length of the season for making the Indigo at four or at most five months in the year.

The leaves of the plants raised from seed in my garden, did not yield colour till several years old, and then but in a trifling degree, and of a quality inferior to what the old wild plants do in their natural soil. It is the same with the young plantations in Bengal. If the leaves are culled, and only the best chosen, the Indigo is considerably more beautiful than when taken promiscuously, with the extremities of the branches, where some (the lowermost on the shoots, will be rather too old, some at the extremities too young, and those on the middle part only of a proper age. I could never extract any thing like blue Indigo from the tender shoots of this plant, when deprived of their leaves. Many trials were made, and in various ways *, because I considered it of importance to determine this point, that care might be taken to prevent the labourers from plucking them, which they will always do, if not strictly watched, because they can fill a basket, or measure, by which they are purchased much sooner, if permitted to bring the twigs along with the leaves, than if leaves only are taken, and the manufacturer will find it necessary to attend particularly to this, otherwise they will always gather the twigs with the leaves upon them, which will diminish the produce of Indigo, and

* This is not the case with the twigs of the common Indigo plant; for in several experiments with rain-water, soft well-water and hard-water, I always easily and readily extracted from them, even when deprived totally of their leaves a tolerably good Indigo, though inferior to what was procured by the same process from the leaves alone. That from the twigs being much more darkly coloured.

debase

debase its quality. However, it will be almost impossible to pick only the leaves excepting when the work is upon a very small scale. All that can be done, in extensive works, is to prevent the twigs from being brought. Leaves of all kinds may be taken, particularly if the work is begun early in the season, before any become so old as to be hard and yellowish. These leaves have this advantage, that they may, without injury, be kept for some little time. I have tried this in various ways, and for various periods, up to their being perfectly dry; and found that they give the best Indigo when kept a day or two. After that, when they begin to wither, they yield but a small portion of very bad Indigo, and when quite dry, only a dirty brown fecula. I have been attentive to this point, because the leaves of the common indigo plant bear drying, and keeping without any loss of their quality. It is the practice in some parts of India to dry them before extracting the Indigo. I was desirous to find that the same could be done with the leaves of this tree, because, when dry, they might at much less expense be transported from one place to another; I must, therefore, confess that I was sorry at the disappointment. This appears to me to be the second essential point in which they (the leaves of nerium and indigofera) differ in their properties. I consider the first to be their not yielding their colour to cold water, or but in a very imperfect degree.

The leaves being collected, for instance, on the preceding day, are put into the coppers, or other vessels, in sufficient quantity, (full) but not pressed down, and then the vessels are filled with cold water *, to within two or three inches of the

* I have tried all the sorts of water that I could conveniently procure, viz. rain-water, soft water from wells and from a river; and various kinds of

the top, and so much must be left, because here the bulk enlarges by the heat, fully as much as the common Indigo vat

of hard water. The last I have generally found to give the best Indigo, and in the largest proportion. The hard water that answered best, has the following properties:—

1.—It is from springs more or less deep, according to the level of the ground, and is very common along the skirts of the mountains, where the nerium grows. Our wells, in the garrison of Samulcotah, are of the same quality; and, during the dry season, are from forty to fifty feet to the water.

2.—It is naturally very clear when undisturbed.

On being heated it appears full of bubbles, as if boiling, while not hotter than the hand can bear. Fifty pints of this water was evaporated to dryness, in a very clean, wide-mouthed brass vessel. During the evaporation, the surface is covered with an ash-coloured granulated cream, and a white sediment is early formed. When reduced to about three or four ounces, it becomes of a brownish colour, and had a saline sweetish taste. In this state it was suffered to remain all night, with a view to discover if any crystalization would take place, as the form of the crystal might better lead to a discovery of their nature; but nothing of the kind took place, I therefore concluded all the salts to be deliquescent. The precipitate, which was gray, like powdered lime-stone, fermented briskly with the diluted mineral acids. During the fermentation with vitriolic and nitrous acids, it emits a strong muriatic smell. The whole being evaporated to dryness, it weighed two hundred and twenty grains; in a moist atmosphere, it absorbs as much water as renders it nearly liquid, making a good hygometer.

3.—Lime-water renders it instantly milky, and causes it to emit much precipitate. Pure caustic, mild alkalis and soap have the same effect; only with this difference, that in soap it is rather a flaky fecula, which is long suspended in the water. But lime-water which has been digested on Prussian-blue, produces no change, which not only proves the total absence of iron, but that the nature of the lime-water has been entirely changed by the blue.

4.—Mineral acids do not cause any change.

From the above analysis, though very incomplete, I do not hesitate to assert, that the cause of hardness in these waters is chiefly, if not entirely, owing to the calcareous matter, held in solution by an excess of fixed air. The other saline substances are in a very minute proportion; a small portion

vat does by fermentation. The fire is then lighted, which must be maintained rather briskly till the liquor acquires a deep green colour when viewed in the vessel; but if taken up, and poured from one vessel into another, it will appear of a pale, but bright greenish yellow; the leaves will then begin to assume a yellowish colour, and the heat of the liquor will be of about one hundred and fifty, or one hundred and sixty degrees of Fahrenheit's scale. Little dependence can be placed on the copper, or violet scum, as the leaves must be constantly agitated, and turned upside down, to produce, as nearly as possible, an equal degree of scalding, if not those at the bottom would be much overdone before those at the surface were ready. The motion answers another purpose, it serves to expel the fixed air, which greatly forwards the operation. The fires must be withdrawn, or suffered to die away, some little time before the liquor has acquired the above-mentioned appearance; and it is necessary to have all the different vessels, that are to be let into the same agitation vat, ready at the same time: a little practice will soon render this easy of performance. When they are ready the whole is drawn off at once. A contrivance must be made to let the liquor pass through a hair-cloth (a coarse Comly, such as the poorer classes of the natives wear in cold weather, answers remarkably well) to prevent any of the leaves, &c. getting into the agitation vat with it. As soon as the whole is run off, it must be, while hot, agitated in the common way for a few minutes; from five to twenty will generally be found sufficient to produce the necessary degree

tion of marine acid, I conceive to be the acidifying principle, which accounts for the deliquescence of the whole. It is well known that a certain proportion of fixed air, renders these substances (calcareous) insoluble in water. A farther addition (an excess) dissolves it, but it is again readily decomposed by heat, &c.

of

of granulation. About from one-seventieth to one-hundredth part of strong, pure lime-water, is then let in (the liquor being still hot) from the lime-water cistern, which requires only to be sufficiently mixed with the liquor, to produce, quickly, a very large grain, which soon precipitates. The supernatant liquor is then let off, and the rest of the process is exactly as in making the common fermented Indigo.

If the process has been properly conducted, the supernatant liquor will run off of a clear Madeira wine colour, which is a sign that it retains none of the Indigo; and the produce of Indigo when dry, will average about one pound from every two hundred and fifty pounds of the green leaves; but varies according to the season and state of the weather when gathered. By the end of August, or September, they have not, with me, yielded much more than one-half, or two-thirds of the quantity which they give in May and June; and even that is diminished if the weather is wet, or if the leaves are committed to the fire immediately when gathered.

The operation was with ease performed twice a day, indeed it might be done three times. The scalding of those large vessels, to the degree already mentioned, requiring only about three hours, and the agitation and precipitation not more; so that by the time the scalding is completed, the fecula of the preceding operation is ready to be removed from the large agitation vat, into the small square cistern, where it is to remain until the fecula has precipitated into a still smaller bulk. The supernatant liquor is then let off by scuppers, and the fecula put into bags to drain.

M. De Cossigny, in his treatise on the cultivation and manufacture of Indigo, observes, that it is much improved if the moist fecula is washed with warm water, in which a

small quantity of the acid of vitriol has been mixed, which may be affirmed also of this Indigo; I would, therefore, recommend the practice, when the acid can be had on reasonable terms. A small quantity will suffice; the use of the acid seems to be to dissolve any remains of the calcareous precipitant, or other extraneous matter that may unavoidably be mixed with the fecula; all of which ought to be farther washed off, by one, two, or even more subsequent washings with pure water; if hot, the better. The marine acid, I have found to answer nearly as well, but as it is weaker, of course to produce the same effect a larger quantity must be used. The nitrous acid did not, with me, produce effects so good; and it rendered this Indigo porous.

No doubt, these washings reduce the produce much; but the beauty and value of the Indigo is greatly increased. Of different samples of this Indigo, which I sent to London, those that had been so treated, were valued at one-fourth more than the same Indigo that had not been washed. This, with the difference in the freight, caused by the greater value of the Indigo, will, I trust, be sufficient to induce manufacturers to give this, regenerating, or improving part of the process, at least a fair trial.

This Indigo, when good, is very friable, it no sooner begins to be dry, than it breaks down into small pieces, even without being touched; for this I have not yet found any remedy (it requires one, as this diminishes its value when brought to market), except that of drying it very slowly in a cool shade, where the sun has no access, for the more it is exposed to his beams, the more friable it becomes. Several parcels of nerium fecula dried quickly in the most powerful sunshine, where compared with other parcels of the same fecula that had been dried very slowly in a cool dark shade; there was no difference in the colour, but the

first

first had fallen into small pieces, whereas most of the second that had been dried slowly in the shade remained entire.

With respect to its quality, it is necessary to observe that, samples have been sent to London, to the Honourable the Court of Directors, to James Amos, Esq. of Devonshire-square, and to different merchants and brokers, and all agree in declaring it to be of excellent quality. Among others, I sent twenty-five different samples to Mr. Forbes, of Aldermanbury, whose broker had them valued by eminent dyers; the price they put upon the worst was four shillings the pound; and on the best, eight shillings and sixpence. The following extract of a letter from H. Harris, Esq. dated Calcutta, July 9, 1791, furnished another proof of its excellence. "I cannot help taking the first opportunity of informing you of the report made to me by my broker, on the samples of Nerium Indigo, which you sent me, viz.: That they had been shown to two eminent dyers, who said that they could pronounce without any trial, that the quality was of a very superior nature, and as good, if not better, than what they had ever seen from India; and that it would be an excellent substitute for Spanish Indigo, and was worth, at that time, eight shillings per pound. I sent the samples by the Houghton Indiaman, and my letter from England is dated January 30, 1791."

The quantity that may be made annually will, of course, now become the next object of inquiry. I have already observed, that the tree, or bush, is found in great plenty about the hilly and mountainous parts of the Circars and Carnatic; so much so, that from what I have seen and heard from others, I may safely venture to say, that any quantity of the Indigo may be made; as a proof of this, I need only observe, that from the 15th of May, till the 15th of August,

1792, I caused to be made from the bushes that grew on one hill; the base of which might be from two to three miles in length, and about one in breadth, no less than between seven and eight hundred pounds weight, the worst of which (and there is but little of this sort) is worth from five to six shillings per pound. The greater part is equal to the sample which was valued at eight and sixpence; and there is a considerable part of it, which was brightened by the acid of vitriol, considerably finer, I conceive worth ten shillings. The apparatus with which the above Indigo was made was such as I have already described, and found to answer well.

I shall now conclude this, the practical part of my paper, with observing, that I have been as minute on every point as my knowledge of the subject permits, with a view to encourage others to undertake the manufacturing of this kind of Indigo in preference to the common kind. It is infinitely more profitable, and (what may seem paradoxical to assert) employs infinitely a greater number of hands in gathering, and bringing the leaves, cutting fuel, &c. which with every man of feeling will be an object in a country where thousands of poor miserable creatures are constantly in a state of starvation for want of employment. The whole of the expense, excepting the first price of the copper for constructing the scalding vessels, goes to the labourers; and what is still more, the old and infirm—the young and feeble can, with ease to themselves, procure a comfortable subsistence by picking the leaves from the bushes, which is the most tedious part of the work, and requires the greatest number of hands, while the stronger are employed in carrying the leaves to the works, cutting and bringing fuel, &c. In short, it seems an object very deserving of the attention of Government. It is in every point of view an object of

great

great magnitude; for, admitting over the whole of the Company's possessions on this canal, only two hundred and fifty Nerium Indigo Works, each making four thousand pounds of Indigo in the season, amounting in all to 1,000,000 lbs.*; which, without exaggeration, may be valued here at two current rupees per pound, and will bring the whole to be equal to 2,000,000 current rupees; half of this sum may be supposed to go for the labourers, which may absolutely be deemed a *charitable donation*; the other half goes for the first cost of the works, and for the manufacturers profit. Hence a source of wealth hitherto unknown, raised in the most laudable and politic manner, and without encroaching on one foot of land that ever has been devoted to other purposes; raised too upon a soil that never can be cultivated, I now speak from experience, not conjecture, which, however, was not the case when I wrote my first account of the tree: I therefore said but little. Now, when I know the quality and the value of the Indigo; the quantity that may annually be manufactured, and the rate at which it can be made, even when entrusted to the management of the natives, to which a necessary attention to many other objects obliged me to have recourse; I say now, when I know these circumstances, I can, with more certainty pronounce

* It appears, from an account published at Paris in 1770, that St. Domingo alone exported annually 2,000,000 lbs. of Indigo, which paid export duty. I may, therefore, conclude that the above calculation is fairly without bounds; for the extent of the country on this coast (Coromandel) where the bush grows, is greater than the whole of the island; and, I have no doubt, that it grows in still greater abundance on the Malabar coast, which is more mountainous, and of course more favourable to the growth of the plant. I have lately been informed that Dr. H. Scott, of Bombay, discovered it growing upon the Island of Salsette.

the manufacture to be a profitable, as well as a laudable pursuit.

The information rendered by Mr. Harris's broker, deposes farther, that two eminent dyers in London, said, *that it would be an excellent substitute for Spanish Indigo.* Mr. Dalrymple, who published my first account of the tree, writes me to the same effect. It is therefore to be hoped that when this Indigo is produced in abundance, Spanish Indigo will be thereby superseded.

This species of Indigo possesses farther advantage. It is well known that the common Indigo plant can be brought to perfection only on a good soil, and by laborious and expensive culture; even then it is liable to many accidents from changes of weather and other causes. I have not discovered that this species of Indigo is subject to any disease; nor have I ever observed a leaf eaten by any insect, or other animal, except goats and buffaloes; and it is only hard necessity that will force them to eat it; for I rarely observed any of the shoots or leaves to have been touched by them, although I have often found large droves of both feeding among the bushes.

A brief Account of the Result of various Experiments made with a view to throw some additional Light on the Theory of this Artificial Production.

In conducting these experiments I confined myself entirely to such as cannot be well practised in Europe, because none of the Indigo plants which I have used grow spontaneously there. For although they can be caused to grow,

grow, yet the climate being so different from that where they are found indigenous, their juices must be weak, and very unfit for yielding good Indigo; such experiments are therefore inapplicable to them, not so with the Indigo itself, for it can be had every where equally good: I therefore avoid touching upon it, as it can be analized by those who are possessed of far more ability for so arduous a task; indeed it is with great diffidence, and with some degree of reluctance, that I have ventured to communicate the result of my experiments on the theory of this manufacture, because I am perfectly sensible of my own inability. My remote situation from the seat of science renders my knowledge of the late improvements in chemistry, particularly of the gases, or aëriform fluids, very limited; and my apparatus for conducting the experiments are at the same time extremely rude.

M. De Cossigny, if I rightly understand, supposes volatile alkali to be the agent or medium by which the colouring matter is extracted from the plant, and held in solution until volatilized by the agitation process:—None of my experiments countenance this theory.

I have lately seen an extract from another ingenious French author, M. de Irom la Cautour, who thinks that the odorous principle of the plant acts the part of M. de Cossigny's volatile alkali. This principle is too fugacious and transient for me to pursue.

Mr. Robert Blake, of Calcutta, in a short paper, supposes the colouring principle to be held in solution by the aërial carbonic acid. If he means the base of the Indigo, which is furnished by the plant, his opinion agrees with my experiments. Mr. Blake was induced to make the experiments that led to the above theory in consequence of the opinion of Mr. Charles Taylor, of Manchester, that this acid was absorbed

absorbed from the atmosphere during the agitation. Mr. Taylor, in his report to the Lords of the Committee of the Privy Council for Trade, &c. says:—"The use of the violent agitation in the second process I think has never been clearly ascertained in any account I have seen respecting Indigo; its theory certainly depends upon the great attraction which Indigo, in that state of solution, has for fixed air; by agitation and exposure to the atmosphere it absorbs it from common air, and unites with it, and is thereby precipitated. The success of this part of the business therefore will be increased by such improvements in mechanics as will expose the coloured liquor with the largest possible surface to the atmosphere, that the affinity may sooner take place, and in procuring a great circulation of common air in and about the reservoir."

In so far Mr. Taylor and I coincide, that we both recommend the exposure of a large surface of the coloured liquor to the atmosphere, and a free circulation of air, which indeed is one of the main objects aimed at.

When the common Indigo plant is committed to cold water in the steeping vat, the appearances are as follows:—In a few hours, more or less, according to circumstances, a slight motion begins to pervade the body of liquor in the vat; the bulk increases considerably, with some additional heat; air bubbles are generated, some of which remain on the surface; these gradually collect into patches of froth—a thin violet or copper-coloured pellicle or cream makes its appearance between the patches of froth: soon after the thin film, which forms the covering of the bubbles that compose the froth, begins to be deeply tinged with fine blue. The liquor has, from the beginning, been acquiring a green colour, and now it will appear, when viewed falling from one vessel into another, of a bright yellowish green,

and

and will readily pass the closest filter, until the action of the air makes it turbid; a proof that the base of the colour is now perfectly dissolved in the watery menstruum. This is the time for letting off the vat; if suffered to remain the bulk begins to diminish and returns to its original dimensions; however the fermentation continues: there is still much intestine motion through the vat, and large quantities of froth is formed. Hitherto the peculiar smell of the plant prevailed; but now it becomes very offensive, something like that of animal matter beginning to putrify; as fermentation goes on the smell becomes more and more offensive, and the quantity of air discharged less and less, till absorption takes place.

For my experiments I used a cask of sixty-three gallons, which I filled two-thirds with the plant, in the state similar to that in which it is directed to be taken to make Indigo, and filled it to within a few inches of the top. To the mouth or bung-hole of the cask I occasionally applied a glass tube, which was always removed immediately after I had collected sufficient air to make the necessary experiments, in order that the external air might have free access to the fermenting mass; that being one of the conditions necessary to promote fermentation. It is unnecessary to detail the periods at which the experiments were made, because the fermentation takes place sooner or later, according as the vessel has been lately employed for the same purpose or not; the reason of this is obvious, and well known to the manufacturers of this commodity as well as to those of wine, rum, and vinegar. During the first part of the process, if a wet bladder is tied over the mouth of the tube it is strongly pressed in by the external air, a sure proof that the vat in this state absorbs air; but as soon as the bulk of the mass begins to be enlarged, a disengagement of airs takes place; these are fixed,

pure

pure and impure, about the time that the bulk of the vat is greatest, the fixed air is discharged purer, and in larger quantities than at any prior period, and even it continued to predominate up to the ninth day, which I call the last stage; but as the fermentation advanced a little beyond the stage at which the vat is to be drawn off, a little agitation was necessary to promote a sufficient discharge of the airs to fill a bladder or two. I tried every means I could invent to detect the volatile alkali that I was led to expect, but without the smallest appearance of success at any time; fixed air was ever present, and in a large proportion, consequently alkaline air could not form a part of these airs without producing white clouds, and a precipitation of mild concrete volatile alkali *.

Not satisfied with this proof, I at various times threw into these airs, confined in inverted glasses, sometimes over water, and at others over mercury, marine acid air, without ever observing the least cloudiness to be produced in consequence.

A farther proof is, that when the nitrous air was thrown in, to prove the presence of pure air, nothing like a white cloud was formed, which would have taken place had alkaline air been present, forming nitrous ammoniac. These proofs are more than sufficient to determine the non-existence of alkaline air; for no two bodies rush into combina-

* In the Appendix to vol. 79 of the Monthly Review for 1788, there are some extracts from the second edition of Dr. M. DE LA METHERIE's Analytical Essay on pure and other species of air; the book itself I have not seen. In treating of fermentation he divides it into two species, one forming *compounds*, as that which produces wine, bread, vinegar, &c. and in vegetables and animals elaborates their juices, and forms of them an astonishing variety of different substances; the other species of fermentation are acid, pure, inflammable, and impure; no notice is taken of alkaline air in these extracts, till speaking of the putrid animal fermentation, during which the airs discharged are acid, pure, impure, inflammable, ammoniacal, and sulphureous.

tions

tions with such rapidity as the alkaline and acid aëriform fluids During the agitation process, fixed air continues to be discharged, mixed with pure and impure airs, but still nothing like volatile alkali, (alkaline air). As soon as the grain appears distinctly, the precipitant (alkaline or calcareous,) is added. From that instant an absorption of air takes place, and after the liquor has settled a little, a candle will burn freely close to its surface as long as it would have done in the same quantity of atmospheric air, which before went out at the instant it entered the mouth of the vessel.

The same experiment was repeated several times on a smaller scale, in bottles of four gallons, and led to the same result.

I also repeated them with nerium leaves; but the fermentation was never so perfect with the common Indigo plant, yet the airs discharged were the same, though in less quantity.

Scalding the common Indigo plant (young twigs and leaves) or the leaves of Nerium in the above-mentioned four-gallon bottles, produces nearly the same effects, viz. first, an absorption of air, then an increase of the bulk of the mass, with a discharge of pure air at first; then it becomes mixed with the fixed air, but in a smaller proportion than in the fermenting mixtures; here also during the agitation much fixed air is discharged, till the grain is formed and the precipitant added. Then, as before, absorption takes place, and, as in the other, a lighted candle burns freely near the surface of the liquor after the precipitant is added; and once I observed distinctly some explosions of inflammable air. If the liquor was agitated previous to letting down the candle into the vessel, it was extinguished at the instant it entered its mouth.

I have determined, as far as my abilities and apparatus permit,

permit, the nature of the airs that are discharged during the solution or extraction of the base of this substance (Indigo,) from the leaves of indigofera tinctoria, and nerium tinctorium, as well as during the whole of the agitation process, an operation which renders this base insoluble in its former solvent, and at the same time separates it from the other extractive matters which have been drawn from the plant by the same menstruum, and which fortunately still remain dissolved, their nature and attractions being different.

I shall now proceed to remark what takes place when the coloured liquor, charged with the green vegetable base of the Indigo, is excluded from the action of the open air, and farther impregnated with the aërial acid.

I took the coloured liquor without being in the least agitated, with which I filled the globe of Dr. NOOTH's apparatus for impregnating water with fixed air, into which I continued to throw that fluid from a fermenting mixture of powdered lime-stone and diluted vitriolic acid. For some hours no change ensued. Standing till next morning a very few grains of a greenish precipitate were found in the bottom of the vessel, which I impute to the communication which the liquor had with the open air before being deposited in the globe; for when the leaves had been scalded in bottles of water inverted in a large vessel of water, or in the globe itself, and committed to the same trial, no grain was found; the liquor remained uniformly of a pale yellowish green, which is the colour it always acquired in my experiments when scalded in the above manner; I kept some full bottles of it inverted in water for a month, and no change took place, nor did the liquor, under any of these circumstances, ever acquire the copper-coloured film on the surface; but as soon as the air is admitted to it, greenish blue veins are soon observed to descend from the surface in various directions

directions until the whole becomes blue; this phenomenon is constant, but the colour is more or less deep, according to circumstances; and soon after a precipitation of blue grains takes place, and the copper-coloured pelicle appears on the surface *.

The experiments were varied with leaves of both Nerium and the common Indigo, and with different kinds of water; the same effects were constantly seen; no change in the colour of the liquor took place, nor was any grain formed, while the external air was perfectly excluded; neither did the leaves acquire that offensive smell which they have when exposed to the action of the air. I may therefore, and I think safely, conclude, that fixed air is not the agent by which this colouring matter is separated from its menstruum, but rather that by which it is extricated from the plant and held in solution.

Nitrous air from iron-filings and diluted nitrous acid was also, by means of Dr. Nooth's apparatus, thrown into the coloured unagitated liquor for some hours, without producing any change, except that here the violet-coloured film took place; this liquor was afterwards exposed to the open air, and the changes which thereupon took place were as usual.

Inflammable air from iron-filings and diluted vitriolic acid deepened the colour of this liquor much, and it was quickly covered with much deep violet-coloured scum, but no decomposition took place till the atmospheric air had access to the liquor; it then became quickly a deep greenish blue, and let fall a considerable proportion of precipitate, which, on drying, turned out to be the most beautiful Indigo. Inflammable air from dried sheep's-blood burnt in

* Some little of any of the usual precipitants always forwarded these changes.

a gun-

a gun-barrel, as recommended by Dr. Priestley, had not the same effect as that from iron-filings and vitriolic acid; the change of colour being less deep.

Alkaline air, from a heated mixture of three-fourths of quick lime and one of sal-ammoniac, deepened the colour of the liquor fully as much as the first-mentioned sort of inflammable air did; it gave a deep violet-scum and good Indigo, after exposure to the open air, but nothing like a separation took place before.

I proceeded in the next place to try the effects of calcareous and alkaline agents on this coloured liquor, still excluding the air; for this purpose I put into bottles portions of the leaves of both plants, to which I added rain water, impregnated with a large portion of what I have always found the most powerful precipitants, viz. lime-water, caustic ley, stale urine, Prussian lixivium, and phlogisticated calcareous lixivium, (the nature of which will be taken notice of hereafter); the bottles were inverted in a vessel of water and scalded to the usual degree; the effects were, that all become only of much deeper colour than when no precipitant was used; but nothing like a separation of the colour took place until exposure to the action of the air.

These experiments were also repeated with different sorts of water, and at different times of the year, with the same success. I also scalded the leaves in an open vessel, and as quickly as possible, so as to allow the air the least time to act on the liquor. I put it into bottles, to which portions of the same precipitants were added, and immediately inverted the bottles in a vessel of water. After standing sixteen hours, a little green or olive coloured fecula, (precipitate) was found in each, which I conclude to have arisen from the little action the air had on the liquor when scalding, and in pouring into the bottles. This precipitate when

separated

when separated and exposed to the air became Indigo of rather a bad quality, and the liquor from whence it was separated, on exposure to the air, became blue from the surface as usual, and soon gave a blue precipitate of tolerable good Indigo. These experiments clearly prove that the most powerful precipitants, added to these liquors, cause no decomposition without the help of the open air; and farther, that if the air has had access to it while scalding only, a very small quantity of green or olive-coloured precipitate may be produced, which does not acquire a blue colour without the free contact of the air. They also prove that the colouring principle of Prussian blue does not act on this coloured liquor any farther than the alkali to which it is united would have done by itself. It is therefore to be presumed, that both the base and the colouring principle of Indigo are totally different from those of Prussian blue.

I shall now proceed to offer such observations on those agents, or mediums, called precipitants, which are generally employed to extricate any remaining fixed air, which may still adhere to the grain after the best conducted agitation, or, as it is commonly called by the manufacturer, to help to form and precipitate the grain. The coloured liquor impregnated with the first principles of the drug, (its base), whether acquired by fermentation or by a scalding heat, will, without the least of our assistance, if only exposed to the open air, and particularly if with a large surface, in a short time begin to part with its colour, which will fall to the bottom in minute grains of fine blue Indigo: agitation will hasten the separation and precipitation much, and cause the produce to be larger. Heat has nearly the same effect, though in a less degree, except when joined with agitation, in which case the two act more powerfully than either alone. The Indigo procured by all these means is good if the process

has been properly conducted; precipitants are not therefore absolutely necessary for the production of Indigo, but if well chosen, and in a proper proportion, they forward the operation much, causing a larger produce than could be had without them, and I have reason, from a variety of experiments, to say, that the quality is by no means injured in consequence. How long precipitants have been in use I cannot say; however it appears from an account of the European Settlements in America, printed in London for R. and J. Dodsley, in 1760, said to be compiled by Mr. Edmund Burke, that the practice of employing lime-water to facilitate the granulation and precipitation was common at that time in America.

So far as I know, these precipitants are universally calcareous, alkaline, or astringent vegetable matters, of which lime-water is the most common; and I believe it is also the best, particularly with Nerium. Alkalies answer the best when made caustic, that is, when deprived of fixed air; but even then lime-water gives a purer Indigo, though probably not in quite so great a quantity. It has been already observed, that fixed air forms a very considerable, I may say the largest portion of the airs that are discharged during the fermentation, scalding and agitation—a fluid for which lime has the greatest attraction. Bergman gives the first place to pure ponderous earth, which I believe some eminent chemists doubt; however all agree in this, that lime holds the second, if not the first place; and upon this principle I conceive the idea of its superiority as a precipitant; for I have every reason to believe that the colouring base of the Indigo is held dissolved by this acid, and the more it is deprived of it, prior to the addition of the precipitant, the more perfect is the granulation, and a much smaller portion of lime-water (precipitant) then answers perfectly well.

Next to lime-water may be reckoned caustic ley, made from vegetable alkali and quick-lime; this generally gives more precipitate, but the quality I found to be inferior to that by lime-water under similar circumstances. I have observed that this ley, when perfectly caustic, throws down some of the other extractive matters of the plant along with or before the blue. If the ley is added before the liquor has been agitated, or before any granulation has taken place, these extractive matters will generally be precipitated first, in form of a dirty pale yellow fecula: in the mean time the supernatent liquor gradually acquires from the surface a deep blue colour, soon becoming turbid, and lastly the blue precipitate of real Indigo will be formed over the first. This proves the impropriety of using a caustic ley where Indigo of the best quality is wanted, which appears to me to be the unequivocal object of every manufacturer. This ley changes the unagitated green liquor into a brownish colour, which quickly becomes blue: these changes are quick, and require an attentive eye to mark them. When this ley is made less caustic, which may be done by using a lixivium of wood-ashes and lime-water mixed, it gives a better coloured precipitate nearly as good as lime-water. At first I supposed this to be the best agent, but farther practice has convinced me that lime-water alone, or phlogisticated calcareous lixivium, are both preferable.

Stale urine is also a powerful agent; the colour of the Indigo precipitated by it is always very bright, but considerably lighter-coloured than with lime-water or caustic ley.

In consequence of observing that inflammable air acted favourably on the coloured liquor, I was induced to prepare and try the Prussian, or phlogisticated lixivium, in various proportions and in various ways; but I could not discover that it proved a better agent than the alkaline ley alone, and in general it was inferior to lime-water; besides its

action is slower: but as I found the caustic ley to be inferior to lime-water, I suspected that the inferiority of this lixivium might be owing to the alkali itself; I was therefore induced to try to incorporate this principle which the alkali receives from the blood, or other animal matters during the calcination with quick-lime. With this view I took equal quantities of unburnt shells in powder, and sheep's blood, and made them up into balls, and burnt them as I would have done the shells alone; with this I prepared a lixivium, which I call phlogisticated calcareous ley, No. 1. I also took equal parts of quick-lime and dried blood in powder; these I calcined together in an open iron ladle until they ceased to emit flame or smoke. With this I prepared another phlogisticated calcareous ley, and to distinguish it from the first, I marked it No. 2. To prove whether these leys contained any of the animal matter, (whether called tinging, inflammable, &c.) I digested some lime-water on powdered Prussian blue until it became of a straw colour, and lost the characteristics of lime-water; I then dissolved a small bit of green vitriol in rain water, which I divided into four equal parts, Nos. 1, 2, 3, and 4; to No. 1, I added twenty drops of pure lime-water as a standard: No. 2, had an equal portion of the lime-water that had been digested on Prussian blue; No. 3, the same number of drops of my phlogisticated calcareous ley. No. 1 and 4, the same number of drops of the ley No. 2. All but No. 1 gave a green precipitate; No. 3 gave rather more than No. 2, and No. 4 more than No. 3. But the colour No. 2 was infinitely brighter than either No. 3 or 4, there being much ochreous matter mixed with them. These two phlogisticated calcareous leys I tried as agents with the coloured liquor of both sorts of the Indigo plants, both before and after agitation, in various ways and proportions, and in general I found that they gave Indigo rather better

than

than lime-water alone. No. 2 I found the best; but after all I do not think this ley could ever be conveniently and cheaply made in sufficient quantities to produce benefit sufficient to induce any one to take so much trouble, independent of expense, as is necessary to prepare it. However I think these experiments prove that the colouring principle of Prussian blue is very different from that of Indigo.

With these phlogisticated agents I have always observed that the supernatant liquor, from whence the blue is precipitated, remains of a much darker greenish or olive colour than when any of the other agents were employed, which implies that there is still much of the base kept dissolved, (by unextricated aërial acid); yet here the produce was fully as great as any of the other precipitants gave with equal portions of the same liquor. At the same time their supernatant liquors proved of a clear brandy or Madeira wine colour. When a green or olive supernatant liquor follows the use of lime-water or caustic ley, (which is too common in making Indigo by fermentation, to the great loss of the manufacturer,) I conceive it to be owing to the presence of fixed air still adhering to and keeping dissolved a portion of the base, this fluid not having been sufficiently extricated by the fermentation, or scalding, extent of surface, agitation and action of the agent employed *.

From a supernatant liquor of this colour, (dark green or olive,) a farther precipitation may be obtained by the same means as used in procuring the first; and it will be found, when dry, of as dark or a darker colour than the first, but

* "This opinion of Dr. R. does not seem well founded; there is much more reason to conclude that from some cause or other the vegetable basis of the Indigo in this case has not attracted and united to itself a sufficient portion of oxygene, on which its blue colour most certainly depends."—Dr. BANCROFT, p. 440.

considerably duller: I never obtained a light blue, except by the means of particular agents; the best of these was soap, if the water in which the herb was scalded or fermented was hard. For if soft or rain water no precipitation takes place with soap. A solution of tin in aqua regia, in a very small proportion, gives a large produce of light blue precipitate. In the northern parts of the coast of Coromandel the natives use a cold infusion of the bark of *Eugenia Jambolana* or *caryophyllifolia* *, very powerful astringents to precipitate their Indigo, which they always extract from the leaves by hot water; they have no idea that Indigo could be made with cold water, nor is it necessary to inform them, for what they make is of a very good quality. I have tried a number of other vegetable astringents, but without any good effect; the principles upon which these act I cannot venture to describe.

The mild vegetable, mineral, and volatile alkalies prove also precipitants, but inferior to those already mentioned. Mineral acids in a small proportion added to the coloured liquor, before or even after agitation, do not prevent the precipitation; but I cannot say they forward it, of course cannot be reckoned agents, or in other words precipitants. Solutions of iron, lead, tin, mercury, and copper, either injure or entirely destroy the colour; tin, if only a very little of the solution is used, gives a light blue fecula of considerable beauty, particularly while moist.

I have also repeatedly tried a very great variety of other substances and various mixtures, not only as precipitants, but to wash the precipitate with, without finding any that can be compared with lime-water for the first, and pure or clear vitriolic acid for the second: it is therefore unnecessary to

* "*Calyptranthes Jambolana* and *caryophyllifolia*."—Linn. sp. pl. ed. Willd. vol. ii. p. 975.

mention

mention them here. I will only state alum, which I have found a most powerful agent, but it debases the quality of the Indigo. With the liquor of Nerium leaves, which had been much scalded, just beginning to boil, it gave a pretty large quantity of green precipitate, which retains its colour after being dried. I have not tried the quality of this green, except as a pigment with water on paper, and it is about as good as Reeves's sap-green; how durable it will prove time must determine *.

From the result of the foregoing experiments I may presume to draw the following conclusions :—

1.—That the two plants afore-mentioned, from which this substance is prepared, yield only the base of it. It is naturally green while it remains dissolved in its watery menstruum, by which it was extracted from the leaves, leaving them of a dirty yellow colour.

2.—That much fixed air is disengaged during the extrication of this base from the leaves which yield it, and is the agent, or medium, by which it (the base) is probably extracted, and kept dissolved in its watery menstruum, and farther, that water naturally impregnated with this acid, and calcareous matter is more capable of extracting a pure colour from Nerium leaves than when not so impregnated.

3.—That to procure a blue (precipitate) Indigo of the best quality from this menstruum, or coloured solvent, such means are quickly to be taken as are known to be most effectual for weakening or destroying that attraction, which fixed air has for this vegetable base. These are heat, exposure to the open air, (solar light,) and agitation, to which may be added such agents as are known to have the greatest attraction for this acid, (fixed air). These are quick-lime and the caustic

* To this discovery I suspect the Barasset, *green Indigo*, may be traced.

alkalies, or their solutions *. The aërial acid, by these means, will gradually quit the base of the Indigo, part flying off by means of heat, exposure to the air and agitation, the rest, (or as much as may be sufficient,) uniting with the calcareous or alkaline agent, forms lime or a mild alkali; the former insoluble falls to the bottom, while the latter is soluble and remains suspended in the liquor: by these means the vegetable base of the Indigo being now completely disengaged unites more perfectly with its colouring principle, which it greedily absorbs from the atmosphere, (and is probably assisted by the action of solar light,) forming therewith a coloured insoluble fecula, which soon falls to the bottom: this precipitate, washed and dried, is Indigo. I cannot certainly determine what this colouring principle is, but suppose it to be Dr. PRIESTLEY'S dephlogisticated air, now called oxygenous gas, pure or vital air. I have already observed, that the natives throughout the Northern Provinces, or Circars, make all their Indigo by means of hot water, which I call the scalding or digesting process, and precipitate with a cold infusion of an astringent vegetable bark; yet, notwithstanding the inferiority of their agent, (which habit has rendered sacred,) when its effects are compared with those of lime-water, which I have often done, their Indigo is constantly found, when not intentionally adulterated, of a very excellent quality, and very light, a cubic-inch weighing only about one hundred and ten grains, the colour blue violet. The superior quality of this Indigo must alone be imputed to the nature of the process by which the colour, (or rather the base of the colour,) is extracted from the plant; for their apparatus is most inconvenient, being only

* I have not been able to procure ponderous earth, otherwise it would have been tried.

common

common earthen pots, which hold about four or five gallons each. In these the fresh tops and leaves of the common Indigo plant are scalded, to a degree a little above what is necessary for extracting the colour from Nerium leaves. They pay little attention to the nature of the water, provided it is clear. Their agitation-vat is only a large jar. The rest of the process is similar to that in common use, but throughout they are very careless, so much so that it is astonishing to find the excellent Indigo which they make in this rude manner. An indubitable proof that the scalding process is superior to fermentation for obtaining good Indigo.

In many parts of the Carnatic they also extract the colour by the same means, hot water; but debase the Indigo, by adding a large quantity of a mixture of red earth and water, which they employ as a precipitant.

These observations on the mode of making Indigo, by the natives of the coast of Coromandel, are given with a view to recommend to our manufacturers the scalding process, in preference. The apparatus for the common plant, may be exactly such as I have described for Nerium; and if they are erected where the Nerium grows in plenty, they can be employed during the hot or dry months on this plant, which is then in season; and during the wet and cold seasons on the common Indigo plant. By this means their works, and what is of more consequence, the labourers, will seldom be without employment; for the land adjacent to the hills, where the Nerium grows, is generally of a good quality, and of a gravelly nature, which suits well the growth of the common Indigo plant during the rainy and cold seasons.

Besides the superior quality of the Indigo, the scalding process has other advantages, the chief of these which present themselves to me, are:—

1.—The

1.—The produce is in general larger, for it rarely happens that the whole of the colour is not extracted at first; when otherwise it must have been removed from the fire too soon.—To be fully master of this department of the art, requires very little practice; whereas, by fermentation, the leaves will yield Indigo upon being fermented a second time. See translation of M. De Cossigny's Treatise on Indigo, pages 145 and 146.

2.—The health of the labourers is not endangered by the effluvia of the manufacture; whereas, from the fermentation, much putrid miasma are constantly exhaling.

3.—The heat employed expels most of the fixed air during the scalding, which renders a very small degree of agitation, and very little of the precipitant sufficient *.

4.—The operation can be performed two or three times daily upon a large scale, which is a very material advantage.

5.—The Indigo dries quickly, without acquiring any bad smell, or putrid tendency, which is always dangerous to health.

6.—Indigo, so prepared, has never that flinty appearance common to fermented Indigo; but in softness and levity is like, or even superior to Spanish Flora.

Explanation of the Engraving of Nerium Tinctorium, Plate 17.

A small branch of the plant is shown in flower.

* M. De Cossigny says, that the Javanese first ferment the plant, then boil a little of the coloured liquor before agitated, and do not seem to make use of any other agent to assist the granulation and precipitation. And that the Indigo itself is very fine, and much esteemed in Europe, which I attribute to boiling alone, probably scalding.

Explanation

Nerium Indigo Works.

Fig. 3.

Transverse Section.

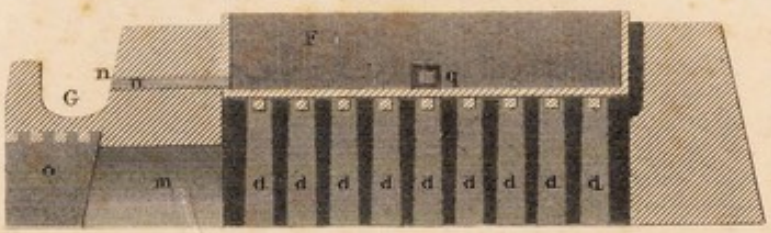


Fig. 4.

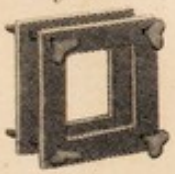
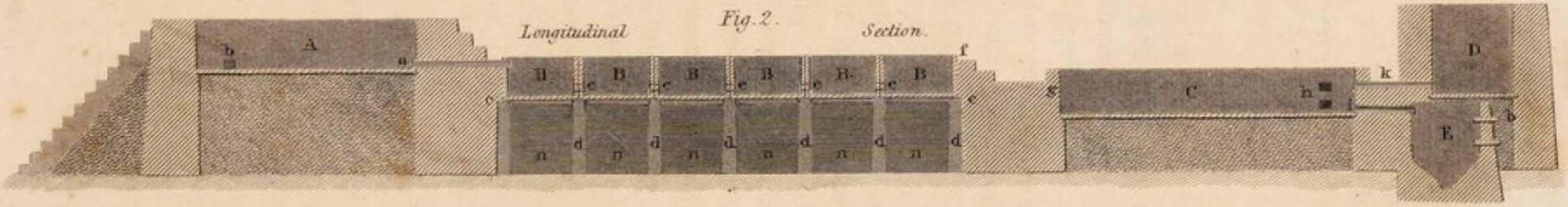
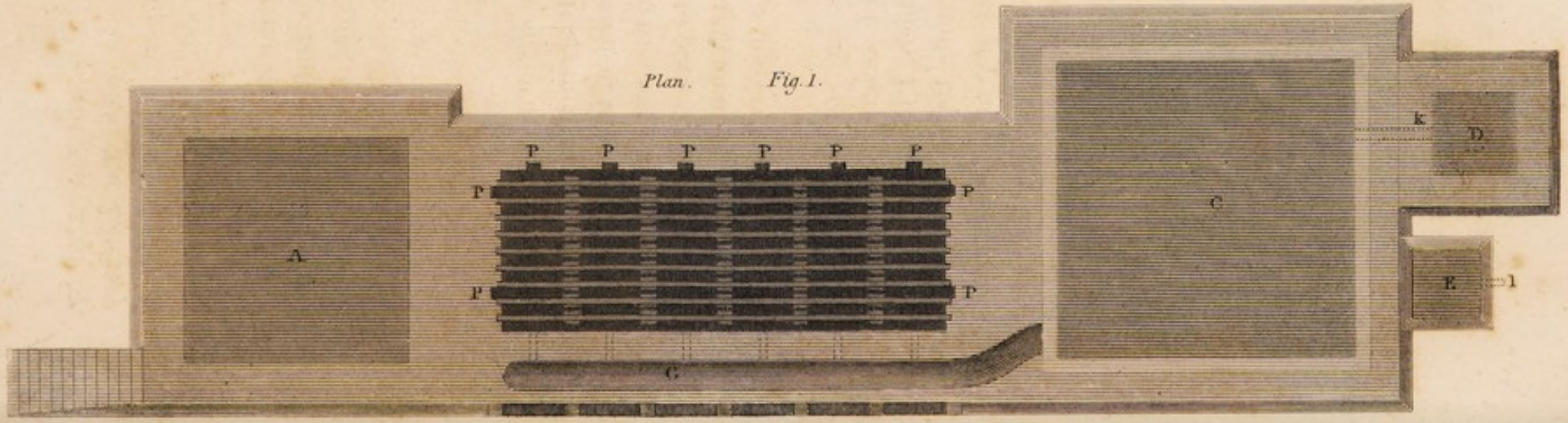


Fig. 2.

Longitudinal Section.



Plan. *Fig. 1.*



Engraved by S. Porter

Explanation of the Figures in the Drawing of the Nerium Indigo Works, Pl. 17 *and* 18.

Fig. 1, pl. 18, the plan, taken at the grate, or iron bars which support the coppers over the fire. The letters are the same as are explained under fig. 3.

Fig. 2, a longitudinal section, which exposes to view the structure of the works.

A, a cistern for holding water in readiness to fill the coppers. It is fifteen feet square, and three deep. *a*, the channel for conducting the water from the cistern into the coppers, which is about two inches above the bottom that any impurities may settle at the bottom; *b*, a channel for the impurities to be drawn off at, and for the cistern to be cleaned.

To raise the water to fill this cistern, is an object of much consequence; in several places amongst the hills, where the *Nerium* grows, there are little rills of water, running upon such a descent as to render it only necessary to construct the works on some low, adjacent spot, that the water may be conducted, with little trouble, into the cistern. When no such supply of water can be had, pecotahs, or a chain pump, made of four boards, as described, and figured in the Encyclopædia Britannica, article *pump*, may be used, or if the water is very low, it may be done with the funnel-like leather bucket, which is wrought by a pair of buffaloes, or bullocks, backing to lower the bucket, &c. To the mouth of the tube, or pipe of this leather funnel-bucket, see *x*, plate 17, is fastened a cord *a*, which leads over a roller, at least, the length of the body of the bucket below the wheel V, over which the rope *y* that raises it passes; and immediately above the trough *s*, by which the water is conducted to the cistern. The cord *w*, is of a length sufficient to keep the mouth of the pipe rather above the square

mouth

mouth of the bucket, until it reaches the roller, which it passes over, leading it into the trough, while the bucket continues to ascend, till its bottom is about the level with the trough, by which time the whole of the water will have made its escape within the trough. This method of raising a large quantity of water from a great depth, is in common use over many parts of Hindostan, where the wells are too deep for the pecotah, or lever. It is of great advantage to have the water in readiness in this manner, for it not only forwards the work much, but also gives time for any impurities to settle at the bottom. In the perspective view the cistern A is omitted, to shew the other parts of the works on a larger scale.

B, the coppers, or scalding vessels. Here they are cut transversely, resting on the grate *c*, which is supported by the walls, and by the pillars *d*. They are made to communicate with each other at the openings *e*; *f* shows the top of the walls which surround the vessels. It is two or three inches lower than the edges of the coppers, to prevent dust, &c. getting in, and sufficiently broad for the workmen to walk about on, to attend the work; *n*, the fire-places.

C, the agitation vat, or beater, twenty feet square, and three deep; one foot of which, *g*, may be called the border, being thinner, and prevents dust and dirt getting in from the feet of the workmen, while walking about to agitate the liquor, &c. *b* two scuppers for letting off the clear supernatant liquor from the fecula; *i*, another to draw off the fecula by.

D, the lime-water cistern, which may be made with a border and lid to exclude the air, or arched, having an opening to put the lime and water in at, and for a boy to go in to clean it. The closer this can be shut, the better will the lime-water be: *k*, the scupper for letting the lime-water into the agitation vat.

E, the

E, the small fecula cistern for the fecula to further settle in: *l*, scuppers to let off the supernatant liquor, and over them the bags are hung till the liquor drops clear from them.

Note, in this section the fecula and lime-water cisterns seem one over the other, but by the plan (fig. 1, pl. 18,) their real places are seen.

Fig. 3, a transverse section, upon a larger scale than the former. It is through the middle of one of the coppers F; and through the middle of one of the arched openings, *m*, pl. 17, which serves to feed the fire. This shews the channel G for carrying the scalded liquor from the boilers, to the agitation vat C, figs. 1 and 2; it is supported by four beams of wood extended between the abutments *n*; one of the scuppers, by which the liquor runs from the coppers to the channel G; *d* are the pillars which support the grate, or square bars of iron; *q*, the opening which communicates with the next copper. To prevent any leakage at these communications, and to be able to separate the vessels, I made use of the following contrivance; it is represented at fig. 4.

Fig. 4, holes are made in the sides of the two contiguous coppers corrresponding with the four screws. A thick square piece of welted hide, with a square hole corresponding with the holes in the sides of the vessels, is slipped in between them, and the two plates of iron are then placed one in each copper, and screwed very tight together. This I have found perfectly convenient, and adequate to the purpose.

Fig. 2, pl. 17, are two of the beaters, each being a square-headed churn-staff, which answers exceedingly well to turn the leaves while scalding, and afterwards to agitate the liquor with; four of them I have found sufficient for the above-described vat.

N. B.

N. B. If workmen for joining the sheathing copper can be had, where the works are to be erected, it would be a great saving of copper, and otherwise more convenient, to have only one vessel; the length may be made as much as may be necessary for the quantity of leaves that may grow in the vicinity of the place. If constructed in this manner, there will be no need of the channel G in front of the vessels, one large scupper from the end of the vessel next the agitation vat, is all that can be necessary. The other parts may remain as above-mentioned. I am now joining my fore-described six vessels into one, by cutting out the divisions, and joining them upon the grate; with the copper so got from the sides cut out I lengthen the now single vessel to be more than forty feet; which will require two additional fire-places, as I conceive a fire for every five feet in length little enough, when the vessel is ten feet broad; which is a surface of fifty square feet for each fire to act on.

Description of a second newly-discovered Indigo Plant, of the same Genus, or Family, (Indigofera, on account of its bearing or yielding Indigo,) to which the sort in common use belongs; with the process for extracting the Indigo, and to distinguish it from Tinctoria, the common kind, and at the same time be expressive of its most predominant quality: I have called it,

INDIGOFERA, *Cœrulea, Roxb.*

Shrubby, erect, hoary.—Leaves pinnate: leaflets from three to five pair; obovate emarginate racemes, shorter than the

the leaves. Legumes reflex, cylindric, curved to rose, hoary three, four seeded.

Carneeli of the Telingas.

This is an erect, shrubby plant, found growing on dry, barren, uncultivated ground, to the height of from one to three feet;—when reared in a good garden soil considerably larger. It flowers during the wet and cold seasons; and the seeds are ripe in about three months.

Description of the Plant.

Stem—erect, woody, as thick as a man's thumb, or more; perennial; height very various, but the whole plant in its wild state is generally about three feet high; when cultivated in a good soil, in my garden, it is often five or six feet high. *Branches*—many, nearly erect, scattered, striated from the insertions of the leaves, three small ridges running down from each, entirely covered with infinite numbers of short, depressed white hairs, which make the plant quite hoary; these may be easily rubbed off, leaving the branches, &c. smooth and green.

Leaves—alternate, somewhat bifarious, numerous, approximate, pinnate, with an odd one; about four inches long. *Leaflets*—short-petioled, opposite; from three to five pair, pale, green, fleshy; the lower smallest; all are obovate, slightly emarginate, with a minute bristle; above pretty smooth, but pale coloured; many, short, oppressed, white hairs cover the underside, which makes it still a fainter green than the upper side; (but nothing like down on any part of the plant;) they are from one to two inches long, and about three-quarters thereof in breadth.

Petioles

Petioles—covered with the same small oppressed white hairs channeled.

Stipules—subulate, small.

Racemes—axillary, solitary, sessile, erect, shorter than the leaves, many-flowered.

Flowers—numerous, small, yellow and red mixed.

Calyx—five toothed; divisions short, acute, equal.

Banner and *Keel*—hairy, greenish-yellow; margins of the former involute.

Wings—pale rose colour, linear oblong. Processes of the keel remarkably large.

Legumes—numerous, reflex, falcate, round, short, covered with the same hairs, the branches, &c. are contracted between the seeds.

Seeds—generally three, smooth, like those of Indigo tinctoria.

From the leaves of this plant I have often extracted a most beautiful light Indigo; more so than I ever could from the common Indigo plant, or from Nerium tinctorium; and in a large proportion.

After an enquiry of some years, I have not been able to discover that the natives of any part of India make any use of this plant.

The process by which I obtained the colour from the leaves, was exactly similar to that practised for obtaining the Indigo from the leaves of Nerium tinctorium, viz. by committing them while fresh to cold water, and scalding them over a moderate fire, to about one hundred and sixty degrees of Fahrenheit's thermometer. The liquor will then have attained a beautiful deep greenish-yellow colour. It is then poured, or strained off clear, and while hot gently agitated in a broad shallow open vessel for 20 or 30 minutes, during which time it changes its colour, gradually becoming

becoming darker and more turbid; when sufficiently agitated, if a little of it be viewed in a clean silver spoon, or other vessel that reflects the light, a muddiness or minute grains may be easily seen; which are rendered large and copious, by the addition of a little lime-water; in which state they readily fall to the bottom. The superincumbent liquor is then poured off, and will be more or less of a clear brandy-colour, according as the operation has been successfully conducted; for the more this liquor is tinged with green, the less perfectly has the colour been separated, and the produce of course the more deficient, and less beautiful. How to effect the most perfect separation and precipitation of the colour, is the grand desideratum with our Indigo manufacturers, and well deserves the Chemist's most serious attention.

Out of various experiments upon the leaves of this plant, the following will be sufficient to illustrate the process:—

September 1, 1792, I scalded eight pounds of the leaves of Indigo cœrulea, in the hard-water mentioned in the first part of this paper, and six pounds and a half in rain water. The operations were conducted as much alike as possible. I have observed, that these require more scalding than those of Nerium, or even of Indigofera tinctoria; for here they were particularly well scalded, till pretty yellow, yet the liquor was then of a less deep colour than it would have been with either of the other two above-mentioned. It also required more agitation to make it granulate; particularly that with rain-water, which, with all the three sorts, seems to act less effectually as a menstruum, than the hard-water. The proportion of lime-water here used, was in both one seventy-fifth part; that is, one of lime-water to seventy-five of the coloured liquor. The feculæ were mixed with a very little diluted acid of vitriol, which was washed off with scalding

soft water: when dry, they proved most beautiful Indigo. No. 1, (hard-water) was considerably the best; but the proportion of Indigo was in both nearly the same, viz.

No. 1.	gave 241 grains, equal to -	$\frac{1}{233}$
No. 2.	199 grains, equal to -	$\frac{1}{230}$
	440 together, or	$\frac{1}{231\frac{1}{2}}$

The samples were sent to the Honorable Court of Directors by the Europa. I could have wished the quantity had been larger, but the scarcity of the plants, and a desire to preserve most of them for seed, prevented it.

I have not yet tried how these leaves are acted on by cold water; but if we may judge from analogy we may venture to conclude, that it will extract the colour, as well as it does from the leaves of the common Indigo plant. This Indigo did not crack, nor break in drying, but remained perfectly entire, and is of a firm texture, notwithstanding its incomparable levity.

January 23, 1793, after a long continuance of dry weather, and strong sea wind, I took seventeen pounds and a half of the leaves of Indigofera cœrulea; some old, some young, and some of a middle age; scalded them in a twenty gallon earthen pot, in the usual way. (The pot was rather crowded with the seventeen pounds and a half.)

As before observed, these leaves require more scalding than those of Nerium. Two thirds of the liquor were taken off, when I judged it at a proper stage; the other third part I suffered to be highly scalded; both were agitated as with Nerium, and as soon as the grain was formed, I added a seventy-fifth part of lime-water. They both precipitated

but

but ill; as the supernatant liquor when poured off was very green. The fecula of both was once washed with a little vitriolic acid, in boiling water. The produce of the first taken off I marked 1, and that of the other 2. No. 1 was rather the finest of the two, a blue purple, and weighed two hundred grains. No. 2, dark blue-purple, and weighed one hundred and forty grains; together three hundred and forty, equal to $\frac{1}{3}\frac{1}{3}\frac{1}{3}$. I conjecture nearly half of the colour remained dissolved in the supernatant liquor which was lost.

January 24, 1793, thirteen pounds of the leaves of Indigo cœrulea were scalded and agitated as usual, with the customary portion of lime-water; but still the supernatant liquor was a deep green; I therefore run it off into another pot, and agitated it for a few minutes, when it again granulated; lime-water was then added as before, by which means I procured nearly as much fecula as at first; half of the first fecula was washed with plain boiling water; it was marked 3. The other half with the help of a little acid; it was marked 4; and the fecula of the second agitation was also washed with the acid; it was marked 5.

	grains.
When dry, 3 was a very beautiful blue-violet, and weighed - - - -	230
4 was a very deep purple copper-blue, which I impute to its having had too much acid, it weighed	120
5 a very fine blue, in respect to appearance, it stands between 3 and 4, and is much more bulky than 3, although the same weight, which was -	230
	580

Here is double the produce of yesterday's experiments; a great portion of which was secured by the second agitation,

and is fully as good Indigo. The proportion here will be one of Indigo to one hundred and fifty-seven of leaves. Had none of it been washed with the acid, I think the produce would have been one of Indigo from one hundred of leaves.

January 25, 1793, twenty-three pounds and a half of the same leaves were scalded at twice in a twenty gallon pot, as usual; but I gave both a much greater share of agitation than is necessary for Nerium, or than I had ever done before with these leaves; in short till almost black, and the grain abundant, and by letting it stand a little in a cup, the liquor could be seen to have lost its greenness entirely. This was gaining a great point; the lime-water was now added; when the precipitate was formed the liquor run off a dark, clear brandy colour; both were washed with the acid, and the first with a second parcel of hot-water. The first scalding of this day, from twelve pounds of leaves, was marked 6. The second from eleven and a half was marked 7. When dry, No. 6, the produce of twelve pounds of leaves, was a most beautiful blue-violet-purple; I think the finest and lightest Indigo I ever saw, it weighed three hundred and eighty grains, equal to one of Indigo from two hundred and twenty-two of leaves. No. 7 weighed four hundred and twenty grains, equal to one of Indigo, from one hundred and ninety-two of leaves. This last (No. 7) had a whitish scurf over it, and when filterating had a blackish pellicle, which I do not well know what to impute to; but the Indigo itself was nearly as beautiful as No. 6.

The produce of the whole of the above three days experiments, came to one thousand seven hundred and twenty grains, from 54 pounds, or three hundred and eighty thousand one hundred and sixty grains of leaves, equal to one part of Indigo from every two hundred and twenty-one of the fresh gathered leaves. No part of the plant but the leaves

is here included, and I have every reason to think, that if the acid had not been used, and the fecula simply washed with the plain boiling water, the produce would have been at least a third more; for I could observe that No. 4 was washed with too much acid, which not only dissolved and carried off nearly half of the Indigo, but also left the remainder of by far too deep a copper-colour. It does not seem to me that this Indigo will require acid, or but a very little, for I think No. 3, where no acid was used, is as good as any of the rest, except No. 6.

January 28, 1793, I sent the greatest part of each sort to Mr. Ross, at Madras, to be forwarded by him to the Honorable Court of Directors, along with my description of the plant.

Description of a third Indigo Plant, viz. Asclepias tinctoria, Roxb.

Shrubby, twining. Leaves narrow cordate. Thyrses axillary, solitary, glomerate. Corol hypocrateriform, with tube rather longer than the oblong nectary, and organs of fructification.

Taroom-akkar, *Marsden's History of Sumatra*, p. 78.

This stately, useful creeper, is a native of the Island of Sumatra, and from thence introduced into the East India Companies Botanic Garden at Calcutta, previous to the year 1793, by the late Colonel Robert Kyd, I presume; and from thence it has been distributed over most parts of India, sent to St. Helena, Europe, America and the West Indies. In the Botanic Garden at Calcutta, and at Samulcotah, it

blossoms during the rains, but does not ripen its seeds in either place. In 1792 Colonel Kyd sent me plants to Samulcotah, where they grow luxuriantly.

Description of the Plant.

Root—ramous, &c. as in most other plants of a similar habit.

Stem—short, crooked, and much swelled at the joints; in old plants as thick as a man's wrist. *Bark*—dirty olive-colour, with small, lighter-coloured, scabrous specks. *Branches*—twining when long, and leaning or scandent when short; their bark smoother than on the stem; young shoots round, and somewhat villous. When wounded, a clear pale yellowish-green liquid exudes, which soon thickens into the consistence of jelly, but in dry weather quickly evaporates, leaving scarcely a trace of its existence behind. When the tender shoots, or leaves are bruised, such parts become livid; a sign of the presence of Indigo.

Leaves—opposite, petioled, narrow-cordate, obtuse, or pointed, slightly villous, margins waved; from four to nine inches long, and from two to six broad. There are some small subulent glands on the upper side, close to the insertion of the petiole; these while young yield a waxy substance.

Petioles—round, from one to two inches long.

Stipules—none.

Thyrses—solitary, axillary, or between the leaves peduncled; as they become old interrupted, from their increasing length.

Flowers

Flowers—numerous, pedicelled, very small, yellow.

Bractes—minute.

Calyx—five-leaved.

Corol—funnel form. *Tube*—gibbous, rather longer than the nectary, and organs of fructification; mouth shut with long, silver-coloured hairs, which form a conic dome, round the apex of the common stigma. *Border*—flat, and cut into five oblique segments.

Nectary—sheathing the fructification, as in the other species of this extensive genus.

Anthers—five pair, and connected by as many short, fine, but firm filaments, to the five small, sharp, hard, black angles of the common stigma; their form is obliquely oval, like the body of a retort, while the filaments represent its neck.

Germs—two superior. *Styles*—two, short. *Stigmas*—proper, two, they are lodged in the base of the common stigma (corpus truncatum of Linnæus) which is of a succulent spongy nature.

Pericarp—I have not yet seen any of them ripe, but have no doubt of their being follicles. In these parts the plants are constantly raised from slips, or cuttings, which accounts for the seed not ripening.

The leaves of this plant yield Indigo, as mentioned by Mr. Marsden, in his history of Sumatra. I have also extracted it from them, and with most success by scalding them in fresh water, till the heat, by Fahrenheit's thermometer, rose to about one hundred and fifty or one hundred and sixty degrees; when the liquor (now a deep clear green) was poured off, and if immediately agitated in the open air, soon became turbid; the more extended the surface while the agitation is going on, the sooner it becomes so. This muddiness, as I have already observed, is, I conjecture,

caused by a combination of the colouring principle of the plant, with oxygen, which it absorbs from the air. If the whole is now suffered to rest a short time, the coloured particles fall to the bottom, leaving the liquor, (if the operation has been properly conducted) of a clear brown colour, which is to be poured, or drawn off, and the blue fecula, dried, forms the Indigo.

If a little lime-water is added to the muddy liquor it hastens the granulation and precipitation of the colour; and with this view is very generally employed by Indigo manufacturers, and often saves time and trouble, and gives a larger produce.

The few experiments I have yet made with this plant do not enable me to say, with any degree of certainty, in what proportion they yield their colour. However, as the plant grows readily from layers, slips or cuttings, I think it very worthy of being cultivated, particularly as it is perennial, like the Nerium; so that a plantation once formed will continue for a number of years; and if I may hint at a comparison between the leaves of this plant, and those of the Nerium, I must observe that the quantity and the quality of the colour they yield will improve as they advance in age and size.

Description of a New Species of Asclepias, which is said to yield a green dye, viz.

Asclepias tingens, Roxb.

Shrubby, twining, bark of the old wood deeply cracked. *Racemes*—spiral. *Nectary* and organs of fructification trochleari

leari cylindric. *Stigma*—oval, crowning the tube of the corol.

A large, twining, shrubby plant, brought from Pegu by Dr. Buchanan in 1795, to the Botanic Garden at Calcutta, where it thrives well, blossoms in June, and the seeds are ripe the following May.

Description of the Plant.

Stems—in six or eight years, as thick as a man's wrist. *Bark*—thereof suberous, and deeply cracked. *Branches*—twining, more or less smooth, according to their age, extending up and over trees, or whatever supporters they meet with.

Leaves—opposite, petioled, cordate, entire, cuspidate, smooth on both sides, from three to six or more inches long, and from two to five broad.

Petioles—about an inch long, channelled, smooth.

Racemes—sub-axillary, solitary, or in pairs, peduncled, while young umbelliform; but as they advance in age and length the slender, smooth, diverging pedicells are seen disposed spirally round the common peduncle.

Flowers—numerous, small, pale, yellow, or cream-colour, when they first expand, but grow gradually darker.

Calyx—to the base five cleft; segments oblong, obtuse.

Corol—hypocrateriform. *Tube*—short, cylindric, as long as the organs of fructification; on the inside run five double ridges, which are ciliate, with short brown hairs. *Border*—expanding; divisions obliquely oval.

Nectary—as in the genus, with the five simple membranaceous, cordate divisions of its mouth, covering the anthers and bottom of the common stigma only.

Anthers

Anthers—five pair, nearly erect, oblong, attached by very short filaments to the base of the five hard black receptacles round the base of the common stigma.

Germs—two. *Styles*—none. *Common Stigma*—smooth, pearl-coloured, oval, tapering much at the base; and round this part ten pits are found, corresponding with the ten anthers.

Follicles—ovate-lanceolate, rather obtuse, spreading smooth, and fleshy on the outside; length about four inches, and one in diameter, where thickest.

Seeds—many, thin, ovate, surrounded by a thin membranaceous edge, and crowned with a coma of soft, delicate white hairs. *Integument*—single, thin, brown.

Perisperm—conform to the seed, thin, white.

Embryo—straight, inverse. *Cotyledons*—thin. *Radicle*—pointing to the coma, which points to the apex of the follicle.

Dr. Buchanan, who brought the plants from Pegu, informed me, that from its leaves the Burmah people prepare a green dye. I hope those people did not forget to inform the doctor that it was necessary to dye the cloth yellow, or blue, either before or after the application of the colour prepared from the leaves of this plant, and that it may be found possessed of what has hitherto been considered a compound colour.

I have made a variety of experiments with a view of obtaining the green dye above-mentioned, but without success. It is therefore unnecessary to state them here. I am however inclined to think it proper to add the foregoing description, and an accompanying drawing, to my account of the *Indigo yielding plants*, described in this paper, that a vegetable, said to possess such a singular property, may be made known, particularly as the information is from so respectable a source

as

as to induce me to hope some person better qualified may be able to discover how this *green dye* is to be obtained and applied.

W. ROXBURGH.

*** From a subsequent communication by Dr. Roxburgh, inserted in the present volume, it will be found that the above accounts of various Indigo plants were only received last year from him, though his experiments were made several years before.—The Society have thought it better to preserve the chemical terms of this account in Dr. Roxburgh's own language than by modernizing them, perhaps to create confusion, as the subject in its present state is sufficiently clear. It is satisfactory to observe, by a reference to the title of this paper, that Dr. Roxburgh's predictions of the probability of immense quantities of Indigo being produced in the East Indies, have been since realized, and now form a considerable part of the Company's investments.

The

The THANKS *of the Society were voted to Dr.* WILLIAM ROXBURGH, *of Calcutta, for the following valuable Communications received from him. Samples of most of the Articles mentioned have been received, and are preserved in the Society's Repository.*

SIR,

I HAVE the pleasure to send you a quantity of my East India fever bark, discovered by me about fifteen years ago; since which period it has had numerous fair trials in many parts, which have been attended with every success that could be wished as a substitute for Peruvian bark, for which I first ventured to propose it.

A figure and description of the tree which furnishes this bark have been published under the name of *Swietania febrifuga*, in my account of Coromandel plants, vol. 1, page 18, table 17. It is a large timber tree, a native of the various mountainous parts of India. You will observe that this bark possesses an agreeable odour, and from numerous experiments which I have made with fresh bark, I have drawn the following conclusions :—

1. That the active parts of the bark of Swietania febrifuga are much more soluble than those of Peruvian bark, particularly in watery menstruums.

2. That it contains a much larger proportion of active, bitter and astringent powers than Peruvian bark.

3. That the watery preparations of this bark remain good much longer than similar preparations of Peruvian bark.

4. That

4. That the spirituous and watery preparations bear to be mixed in any proportion, without decomposition.

5. That this bark, in powder, and its preparations, are more antiseptic than Peruvian bark, or similar preparations thereof.

In my practice I generally gave from twenty to sixty grains of the fine powder in substance, either in wine or water, as circumstances required, and commonly as often as Peruvian bark is usually prescribed.

I recommend that some of this bark may be sent to the fenny countries, where intermitting fevers prevail, and if it is found to answer, which I have no doubt of, it may be imported from the East Indies at so low a rate as to render its use very general, on account of the high price of Peruvian bark.

I am, Dear Sir,

Your most obedient Servant,

W. ROXBURGH.

March 28, 1806.

To C. Taylor, M. D. Sec.

*** From experiments since made in England, the Swietania bark has been found a valuable medicine in intermittent fevers, scrofula, and in disorders usually termed nervous.

DEAR SIR,

I wrote to you lately, along with my papers on the manufacture of Indigo, and of some newly-discovered plants which yield that drug.

It

It appears to me now that it will tend to a useful purpose to put the Society in possession of samples of a very cheap resin, the produce of one of our largest and best timber trees, called by the natives of Bengal, *Saul*, and by me, *Shorea robusta*. It is one of the substances used in our Indian naval yards under the general name *Dammer*, and is a substitute for pitch and tar. To bring it to a proper consistence for such use, it is boiled up with some cheap vegetable oil, (the Hindoos being forbid by their religion to use any animal oil), and more or less of the vegetable oil is added, according to the purpose for which it is wanted. The Society will probably find it also applicable to other uses, as it is a pure resin, cheap and plentiful: the price of it here is from three-halfpence to two-pence per pound. I wish to know whether it has been yet known in England, and whether it is likely to be in demand. It will probably be useful for making sealing-wax, and for varnish.

I am, my dear Sir,

Your's very obediently,

W. ROXBURGH.

Calcutta, Jan. 18, 1809.

To C. TAYLOR, M. D. SEC.

MY DEAR SIR,

I HAVE now sent to you further samples of the resin of my Shorea robusta; and I have also sent a parcel of the black myrabolans, *(Myrabolanus Indica,)* the origin of which has hitherto been unknown. I believe that they are the unripe fruit

fruit of the same tree which produces the *Chebulic myrabolans*, and you will trace the cause of my now having discovered the tree which produces them in part 3 of the eleventh volume of the Asiatic Researches, containing a catalogue of Indian medicinal plants and drugs, with their names in the Hindustani and Sanscrit languages, by John Fleming, M. D. pages 29, 30, and 31, which the author sends to you for the Society. But though their medicinal virtues are in high repute over Asia, I do not send them to you with that view alone, but rather because I think they contain much *tannin* in little bulk, and may therefore be useful, and save the British oak plantations. I fear the gaub-extract, from the fruit of *Embryopteris glutinifera*, which I sent you some time since for the trial of the tanners, may not have answered so well as I expected, otherwise that you would have applied for more of it.

I take the present opportunity to request you will correct a mistake in my letter of June 18, 1804, published in the 23d volume of the Society's Transactions, page 408, where I said *hurra* was the fruit of *terminalia citrina*; I now find it is the fruit of *terminalia chebula*.—See Coromandel plants, 2, No. 197, and of Wildenow's edition of the Species of Plantarum, 4.969. I now send to you a drawing and description of the tree, and of the myrabalans in their various stages, both fresh from the tree and dried as mentioned by Dr. Fleming. The small parcel within the other contains some of the drug purchased in the Bazar, viz. four pounds weight, for which I paid one shilling. The remainder are fresh gathered from two trees in this garden, and hastily dried in the sun; they are rather advanced, and may answer to the fourth, fifth, and sixth sorts of the drawing; and amongst those of the Bazar will be found the three first. I have also sent you some more fever bark, part of

the

the produce of a young tree which grew in this garden. It is difficult to judge how long we may be conveniently supplied with Peruvian bark, and it is therefore very proper that this valuable substitute should be brought into general use as soon as possible, and if it is likely to meet with extensive demand, I will contrive that some of it be sent home for sale.

In the same package is inclosed some bark of a new species of *Brucea*, which is said to be a most powerful medicine; it is the *Lussa radga* of Rumphius's Herbarium Amboinensis, 7, p. 27, t. 15: it is a thin bark, and may probably be as good or better than *Simarouba*. In the same bundle is another parcel, which is the *Conessi bark* of our *Materia Medica*; it has an austere bitter taste, and is recommended in dysenteries, diarrhœas, &c. as an astringent *. I wish to receive the opinion of the Society on these and other articles which I have sent.

I am, my dear Sir,

Your's very obediently,

W. ROXBURGH.

Calcutta, Oct. 3, 1809.

To C. TAYLOR, M. D. SEC.

MY DEAR SIR,

CAPTAIN Richardson having been detained thus long, and this being the season for the gaub fruit, I have made a few

* See further particulars of this bark in Dr. Roxburgh's Treatise of Nerium Indigo, p. 254 of this volume, under the name of *Nerium Antidysentericum*.

pounds

pounds of the extract, which is packed in the same box with the articles mentioned in my former letter. At the bottom of the box there is ten pounds made with cold water. Immediately above it is another stratum, weighing six and a half pounds, made with hot water from the refuse left after the cold water process. These two parcels, with that I sent you formerly, will certainly enable the Society to ascertain and let me know what prospect of success this extract holds out to your tanners. I request the Society will order experiments to be made therewith as early as possible, and I anxiously wait for letters from you acquainting me with the result.—I remain, dear Sir,

Your's truly,

W. ROXBURGH.

Calcutta, Nov. 21, 1809.

To C. TAYLOR, M. D. SEC.

*** Samples of the several articles above-mentioned will be delivered for trial to such persons as will engage to favour the Society with the result of their experiments thereon.

The THANKS *of the Society were voted to Dr.* ALEXANDER ANDERSON, *of the Royal Botanical Garden at St. Vincent, for the following interesting Communications received from him respecting the Plants in that Garden.*

DEAR SIR,

I HAVE great pleasure in informing the Society that lately I have obtained some valuable acquisitions from the liberal

and patriotic views of Admiral Sir Alexander Cochrane, who in the beginning of August sent a ship here to take me on board, or such person as I thought proper to send, to proceed direct to Cayenne, to procure every useful plant it afforded that was wanted for this garden.

It being the commencement of the hurricane months, I found it improper to leave the garden for three months, particularly as the house is in a ruinous state for want of repairs; but my friend and fellow-labourer, Mr. Lockhead, went from Trinidad in my stead. From his knowledge of the Portuguese language he was indeed fitter than me for that service. My great desideratum from that quarter was to obtain the nutmeg-tree, as the one I have in this garden is a male, and of no use alone. I had no doubt but an ample supply would be readily got from the present possessor of that colony, and the Captain of the vessel carried a very polite letter from the Admiral to the Governor there; but such was his illiberal and ungenerous conduct, that he gave neither aid nor countenance towards our obtaining an individual plant of any kind. Fortunately Mr. Lockhead met with a French botanist, from whom he procured three young nutmeg trees, and from his perseverance, combined with that of Captain Dix, of the Cygnet, they brought with them four large boxes full of plants, several of them valuable, amongst which were the *Heveaguianensis* of Aublet, (the *Caoutchouc*, or gum-elastic tree,) several clove plants, black pepper, couma, and bagossa, (Aublet,) some palms, fruits, esculents, &c. To counter-balance the disappointment at Cayenne, Mr. Lockhead generously made me a present of two very fine young nutmeg trees, which he had nursed in Trinidad for three years. Immediately after his return from Cayenne, Captain Dix went to Trinidad and brought them here in a flourishing state, so that if no accident happens to them, they will produce fruit about two years hence.

At

At present the garden possesses six nutmeg trees. I cannot avoid mentioning the great obligation this garden is under to Captain Dix, of his Majesty's ship Cygnet, who instantly embraced the service, when proposed by the Admiral, and used every exertion in his power for the full accomplishment of the Admiral's good intentions.

I am, with great regard, dear Sir,

Your obliged and very humble Servant,

ALEXANDER ANDERSON.

Botanic Garden, St. Vincent, Aug. 21, 1809.

To C. Taylor, M. D. Sec.

DEAR SIR,

I am unable to express my gratitude to the Society for the honour they have done me at different times, and their united interest for obtaining the late allowance from Government to me. It will be my greatest ambition to merit their esteem; your individual friendship has been long known to me.

The two young nutmeg trees from Trinidad are at present in a prosperous state. The true Ipecacuanha plant is a great desideratum with me; and as the communication between England and the Brazils is now open, I should hope that it might be obtained through the influence of Sir Joseph Banks. I wish for information whether the Columbo plant has yet been brought to England from Ceylon, and whether the plant is clearly ascertained by botanists.

I am, with great regard, dear Sir,

Your much obliged Servant,

ALEXANDER ANDERSON.

Botanic Garden, St. Vincent, July 23, 1810.

To C. Taylor, M. D. Sec.

*** By letters from St. Vincent, under date of August, 1810, from Dr. Anderson, Mr. George Young, Mr. J. Sutherland, and Mr. D. Questel, the Society have received information, that on opening a box of plants, sent from London by Mr. Salisbury to St. Vincent, packed in the *Sphagnum palustre*, in the manner mentioned by him in the 27th volume of the Society's Transactions, that the moss appeared to be in a perfect state of vegetation, and of a yellowish green colour on its arrival; that the plants had many of them shot out from their stems, particularly the apple plants, and some from the roots; that the carnations were decayed, and that some of the other plants appeared somewhat injured; but upon the whole they might be esteemed in high preservation; that this is the more to be considered as they must have been taken up in a very unfavourable season for the experiments: they further observe, that the iron wires, with which the labels had been fixed, were corroded and destroyed; they therefore recommend that the labels be attached in future with brass-wire, at least as thick as the largest string of an harpsicord. They add, that from the fresh appearance of the moss they purposed to pack in it some of the plants of that Island, and send them to England.