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A

PRACTICAL TREATISE

ON THE

CULTIVATION OF THE SUGAR CANE,

AND

THE MANUFACTURE OF SUGAR.

BY

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INTRODUCTION.

THE PRESENT CONDITION OF THE WEST INDIA COLONIES,
AND THE EVENTS WHICH HAVE LED TO IT.

THE present deplorable condition of the British Colonies in the West Indies, is a subject of much importance to the nation. It is not only the planters, and the persons actually engaged in the West India trade, who will be sufferers by the continuance of this state of things, because, if our Colonies continue to decay, in the same ratio, as they have done for the last three years, till the time arrives for the equalization of duties, there is every prospect of the trade being monopolized by the Slave-holding States, in which case the consumer will be in a worse position than before the change in the sugar duties, unless means be devised to rescue our Colonies from their embarrassed and ruinous position.

The present abundance of sugar, and its moderate price, appears so satisfactory to those who are not imme-

diately connected with its production, that little thought is bestowed on the subject, and questions concerning the sources of future supply attract little attention.

Various methods have been proposed for rescuing the sugar-producing Colonies, and more particularly the West Indies, from the ruinous condition into which they have fallen. Many partially excellent and practicable plans have been suggested, and projects the most wild and fanciful have been proposed. But, while much has been said and written discursively, there is a want of information of a general and connected nature, as to what is the actual condition of the plantations—what has been the system of production usually adopted—who are the persons by whom this system is directed and carried out—what are the successive steps which have led to the present universal prostration and insolvency—and what would be the most advisable course, under these circumstances, for the Planters to pursue, in order to render available to the utmost, the means they possess. This is of much greater importance than proposals of remedies which are difficult of attainment, involving a vast outlay of national or private capital, and the success of which are at best problematical.

It is my purpose, in the following pages, to show, that the planters possess the means, if properly applied, of aiding themselves to a much greater extent than is generally practised; and that the resources of the Colonies are not sufficiently developed, owing to the imperfect methods of

Cultivation and Manufacture which have hitherto been in use, and which long custom, the apathy engendered by habits of routine, and the fear of failure in the case of attempting extensive reforms, cause to be still almost universally persisted in.

Very few persons agree as to what is the best course to be adopted by the Colonists. A very large portion of that body are of opinion, that nothing which they are of themselves able to effect, would be sufficient to save them from utter ruin, so long as the present policy of Government is persisted in, and the productions of slave-labour admitted to compete with them on equal terms. And this accounts, in some measure, for the apathy and want of exertion which has unfortunately so generally prevailed. The greater number—relying entirely on the undoubted justness of their claim to the assistance of Government, and using all their efforts to obtain this, by endeavouring to enlist the sympathies of the nation in their behalf, and attempting, by petitions and remonstrances, to avert the evil they feared, —did not generally take in time, those decisive measures, which, though insufficient to prevent much embarrassment and loss, could alone be successful in preserving them from ruin.

Another party, who think that the principal difficulty arises, not so much from any fault or imperfection in the ancient methods of production, as from an inadequate supply of labourers, are of opinion, that the great remedy for their difficulties is to be brought about by immigra-

tion, and are only divided in opinion as to the race who are best suited for the climate and requirements of the Colonies. Thus we have advocates for European labourers, for Kroomen, Hindoos, Portuguese of Madeira; and a late writer on the subject extols the Chinese above all others, and thinks that an immediate importation of 250,000 labourers from that empire would prove to be a universal panacea for all the evils that threaten or have befallen the West Indian Colonies.

The experiment of immigration has been tried to a certain extent, and I cannot think it has at all realized the expectations of those persons who have made the trial. The expense of it has been very great, and the benefits derived from it have been not at all commensurate. It may be objected, that the success of the scheme could not be fairly tested because tried on so very limited a scale; but I think it a hazardous experiment to invest so much capital as would be required to carry out a measure, the success of which is doubtful. And, besides, we do not perceive that in those places where the native population is most abundant, as in Barbados, they have been much better off, than in those Colonies where labour has been comparatively scarce. There has been nearly as much complaint of distress and ruin from the Planters of that densely populated island, as from other Colonies much more thinly peopled.

It is possible, that had more time elapsed between the enactment and the operation of the measures deter-

mined on by Government, the Planters might have been able to adopt a system calculated gradually to counteract the ruinous effects of the policy alluded to; but the suddenness as well as the magnitude of the changes which have taken place, have been such as to paralyse their efforts; and the depreciation in the value of property within the last three years,* has deterred capitalists from venturing to make advances for the improvements required, in consequence of the uncertain nature of the security.

It is universally admitted, that the measure of slave emancipation was precipitated in a manner inconsistent with prudent legislation, although a matter which involved interests and issues of such unprecedented and unparalleled importance, that the greatest statesman of the period expressed feelings of embarrassment and anxiety in approaching a question of such magnitude; still, there is little doubt, that had its operation not been followed by the more recent injurious fiscal enactments, the present unfortunate results would not have been brought about.

* The value of property in some of these Colonies is reduced to such a ruinous degree, as in many instances to amount to nearly a total loss; and few purchasers can be found for such estates as are put up for sale, even at a most inadequate price. We have an instance of this in the case of some valuable contiguous estates in Demerara, being offered for sale for £14,000, the value of which, a few years ago, exceeded £100,000; and similar cases could be adduced which have occurred in the other Colonies.

It is impossible to justify the various enactments which effect alterations on the sugar duties, and of which the Planters justly complain, as they are not only in direct contradiction to the avowed motives of the Government in abolishing slavery, but amount to a direct breach of the positive engagements entered into by them on that occasion.

The abolition of slavery had in itself, comparatively, little influence in bringing about the unfortunate state of affairs which prevails, as was evinced by the fact, that property, in some of the Colonies, and particularly in Barbados, where I then was, maintained its highest value for some time after the period of emancipation; and there is abundant evidence, that well conducted estates in all the West Indian Colonies, continued to yield as large a return to their proprietors as at any former period. Estates were leased at even an extravagant rental, and large transfers of property were made without dread or hesitation.

The cause of this temporary prosperity may be traced to the dependence placed by the Planters upon the promised assistance and protection of Government, which they did not regard as a boon, but as an indisputable right—the just claim of a creditor for an admitted debt—because they had received only an instalment of the compensation to which Government had admitted they were entitled, being paid little over one third of the appraised value of their slaves, receiving only sixteen millions out of the forty-three millions, which was the valuation of the crown commis-

sioners. With this admitted claim, the Colonists could not doubt, that in the event of no further remuneration in money being awarded to them, they would enjoy the operation of such fiscal enactments, as would at least be equal in value to their acknowledged claim. If it had been believed at that time, that the present course would ever be adopted, or that so sweeping and sudden a change would ever take place, the Colonists would not have been lulled into a state of false security, and the value of property would not have been kept up at a false standard. Many persons who are now ruined by having invested their capital in West Indian property, would never have embarked in a speculation which would have been deemed too hazardous to be prudent, even at a much lower value : and those who had no alternative would have begun gradually to take such steps, as circumstances rendered necessary, to reduce the cost of production by every contrivance which skill, sharpened by necessity, could suggest.

The question of free trade generally, has been too much mixed and associated with that of the Colonies, and most persons seem to confound them with one another, and consider that the protectionist party in this country, and the West India body, are one and the same. There exists, however, a wide distinction. The latter demand not one particular policy or another ; they ask only for the fulfilment of the promises made to them, to which this country was solemnly pledged, and which they must obtain before

they are on a footing with the proprietors of land in the mother country.

In order to understand the exact nature of the claims of the Colonists, it is necessary to revert to the circumstances attending the passing of the act for the abolition of slavery.

In the first place, the right to hold property in slaves must be considered as admitted. This is placed beyond doubt by the manner in which slavery originated in our West Indian possessions. We find, by reference to the laws of the period, that grants of land were given, on the express condition, that a certain number of slaves should be settled and maintained thereon, and these slaves were sold to the settlers by British subjects, under the authority of Government. Numerous subsequent acts recognised and confirmed the property thus created.

The legal right to the possession of property in slaves, was therefore indisputable; it was fully recognised by the State, in their directing an appraisement of their value, with a view to compensate the proprietors; and it was finally determined to award them a limited grant of money, and to secure to them such advantages of a fiscal nature, as would equal in value their remaining claims.

The feeling which originated the abolition of slavery, was creditable to the nation, and although the measure might have been perfected, in a greater degree, by a more wise and cautious legislation, there can be no doubt that

the Colonies would have continued to be prosperous, and that such gradual improvements would have taken place in their resources, and such an increase in the amount of their productions, as would have enabled them to supply sugar in sufficient quantities for any amount of consumption in this country, and that they would eventually have been able to compete with slave-holding states in such a manner as to ensure the extinction of slavery.

It is impossible to deny, that the effect of competition is to cheapen production, and to stimulate those engaged in it, to the utmost energy, in developing and economizing their resources, and in effecting and adopting such improvements as necessity suggests. But if one party possesses advantages which are placed beyond the reach of the other, it is useless to commence a struggle, the evil result of which may be foreseen. But this view of the case seems to have been disregarded by those who legislated for the Colonies, while effecting the changes in question. They have evidently been influenced by the idea, that competition with foreigners would excite industry, and increase production, and they appear entirely to have overlooked the fact, that the competition is unequal, and can only, therefore, be productive of benefit to those possessing the greatest advantages; while its effect is to paralyse the industry of the less favoured party, and, as has been rendered apparent, by destroying their credit, to reduce them to a state of ruinous inaction, and prevent them from adopting many of the improved modes of manufacture, of

which their more favoured rivals are eagerly availing themselves, and thus adding to the advantages they already possess.

It is abundantly evident, then, that the principles of free trade cannot be with justice applied to the West Indian Colonies in their present condition, and that the claims of the Colonists are based upon the broad principles of equity and national good faith, and *are altogether irrespective of legislative policy.*

The Government have an undoubted right to legislate in accordance with the wish of the majority of the English people, and that right they exercised in abolishing slavery ; but they have no right to confiscate property. If it is necessary to destroy the property of individuals for the public good, it is also necessary to compensate them for the injury sustained, and, therefore, in removing the advantages of a fiscal nature, which were considered as a portion of the compensation to the West India proprietors, it is but just that they should have an equivalent pecuniary remuneration. When this is done, it is time enough to talk about the free trade question, as affecting the Colonies with the empire generally, and with which the present demands of the West India proprietors have nothing to do. If the duty on foreign sugar was kept up in their favour, they would not be embarrassed ; if, that being removed, an adequate pecuniary compensation was made, they would be in a position, by the investment of it in stock and machinery, to render themselves independent of any reduc-

tion in the value of sugar caused by equalization of duties, by reducing the cost of production in the same ratio, and increasing the value of the product by improved methods of manufacture.*

It cannot be denied, however, that the Planters have not in general availed themselves of such improvements as were within their reach. Some spirited and intelligent individuals, in almost every Colony, have seen the necessity of reforming the old systems of Cultivation and Manufacture, and their efforts have, in most instances, been as successful as could be expected, under the circumstances of their struggling, for the most part, single-handed, unsupported by adequate means, and having to contend against deeply-rooted and widely-diffused prejudices. And I have no doubt, that had there been more combination in the march of improvement, and more attention paid generally to the adaptation of the means they actually possess, dark as are the prospects of the West Indians, they would not

* An aggravation of the injury complained of by the Colonists, is its sudden and unexpected operation. Had any warning of such intention been given at the time of slave emancipation, measures might have been taken, and preparations made, to meet the difficulty when it arrived. And as the only chance of competition with the productions of slave-labour consisted in a complete change of the whole system of Cultivation and Manufacture which had hitherto been practised, and with which the persons engaged in it were alone conversant; and when it is known how extremely difficult it is to effect such changes in routine systems, even where the urgent necessity is evident, the glaring injustice of such aggravated wrong is so apparent as to require no comment.

be reduced to the utterly ruinous condition in which they are placed at present.

The efforts of Lord Elgin, and others of the Colonial governors, in promoting the formation of Agricultural Societies, and otherwise encouraging the extension of knowledge and improvement among the Planters, are deserving of great praise; and in some of the Colonies much progress has been made in effecting improvements, and bringing to aid such implements of husbandry as tend to reduce the necessity for manual labour, and such improved methods of manufacture, as to ensure a more valuable product.

It is doubtless a subject of much wonder, that where it has been shown by examples of this nature, how much can be done to cheapen production, the general practice should be so little altered, and, with the exception of a limited number of spirited and intelligent individuals, the proportion of whom have varied much in the different Colonies, so little real progress should have been made.

There is a consideration, however, which, I confess, has tended very materially to diminish my own astonishment at the fact. My experience has convinced me, that sufficient regard has not always been paid to the qualifications of the parties to whom the care of estates has been intrusted. I am far from insinuating any thing against the probity, or even the industry, of this class, but the fact is, something more than these qualities, valuable and important as they are, is needed to make a good Planter. The character of

sugar cultivation has been mistaken. It is not, as has been too commonly supposed, a mere mechanical process, but it is an art, demanding, for its due development, more than ordinary sagacity and intelligence. Formerly, indeed, estates were managed on principles which never even supposed the admissibility of change, or the possibility of improvement, and it is to be regretted that the same course still very generally prevails. For conducting such a system, no great talent was required—nay, if a manager wished to enjoy the good opinion and confidence of his employer, it was his interest studiously to avoid suggesting alterations, and make it his grand object implicitly to follow his instructions, without venturing to express an opinion on their expediency.

The chief direction of West Indian property was vested in the Attornies or agents of the absentee proprietors. The most eminent and active of these had been selected from the most industrious of the managers, or from the relatives of proprietors who might be resident in the Colonies, and were for the most part admirably adapted, by their energy of character, to carry on the routine system which prevailed. But, being for the most part deeply prejudiced in favour of the existing methods, (a feeling which a long course of routine seldom fails to establish, and which has been exemplified as much in the case of many of the old class of English farmers, as in that of the Planter,) and satisfied that no change of system was required, or at least, not feeling that they would be justified

in attempting any, they were not calculated to make any advance towards a more rational and economical method of management. Hence, when a change of circumstances rendered all their efforts unprofitable, they did not take those steps which the exigencies of the times demanded, to avert the ruin which a persistence in the old and imperfect practice threatened to accomplish. In fact, the change paralysed them. All that has been done by most of them, has been, to practise economy on a small scale, by reducing the salaries of subordinates, and battling with the merchant for reduced freight, and with the labourer for lower wages, not being able to understand the more comprehensive economy which is required.

I speak, of course, merely of what has fallen under my own observation, but I perceive that a late writer, in speaking of the practice in Jamaica, after using even stronger language on the subject, remarks as follows:—

“There is no communing with the overseer in regard to the welfare of the estate—no exchange of advice betwixt overseer and attorney, or at least none which merits the title. In fact, the whole system is quite opposed to such confidence and consideration. The attorney employs an overseer who will manage the property precisely as he directs, and who will bend to him in all things. The overseer, on the other hand, seeks to conciliate the goodwill, and secure the countenance, of his employer, the attorney—the only employer whom he knows, by doing all in his power to please him. He knows, that at any

moment, with or without a reason, the attorney may discharge him. Is it to be wondered at, therefore, that he is cautious of saying or doing ought offensive, when it could only lead to his own loss of employment, and attendant injury? Of course, it will be understood that there are many attorneys who are exceptions to the above rule, which, I am very sorry to say, however, is still but too general. Nor do I intend to assert that a very strict supervision is not necessary. On the contrary, I consider a proprietor or agent cannot exercise too much vigilance, or interfere too often, when he finds things going wrong on an estate. But I think that an overseer should be brought to identify himself with the property of which he is in charge—that he should regard it as his comfortable and undoubted home, which he feels is secured to him by the good feeling and interest of the proprietor or agent. Were such a feeling called into being, and carefully fostered, many very great benefits would result. For instance, take an intelligent and right-minded man, of education and experience, and place him in charge of an estate, giving him an honest account of its pecuniary position, a clear idea of what is expected from him, and a genuine assurance of confidence, security, and indulgent consideration, and I feel convinced that he would study economy in the general management of the estate, and employ the energies of his mind in compassing its gradual improvement, instead of speculating on the advent of a *successor*. At present, the great aim of an overseer is, to keep his situation, which is

generally of so insecure a tenure, that he thinks it a folly to enter into calculations which require time to carry out. It is a most injurious system, and should at all risks be altered, for without feeling a heart-in-hand kind of interest in the estate that he manages, the overseer can never act the part he ought."—*Wray's Practical Sugar Planter*, page 62.

PART FIRST.

ON THE CULTIVATION OF THE SUGAR CANE.

CHAPTER I.

A DESCRIPTION OF THE METHODS OF CULTIVATION USUALLY PRACTISED IN THE WEST INDIES.

THE old system of cane cultivation is too well known to need description, but for the sake of comparison, I shall briefly advert to it.

The land under cultivation was generally divided into three or more nearly equal portions, according to the desire of the manager, to ratoon once, or oftener; and soon after the termination of the sugar making season, the preparation of the portion of land to be planted in the beginning of the succeeding year was commenced, by putting a gang of negroes with hoes, to break up the surface. This was generally done in a very superficial manner, as the labourer naturally exerted all his ingenuity to give his work the *appearance* of being well performed,

with as little exertion on his part as possible. The size of the cane-hole was defined, by measuring squares of three, three and a-half, or four feet, according to the fancy of the Planter, with a line, and marking off the spaces with small sticks; but generally, the shape of the old cane-hole was sufficient to direct the labourers in forming the new one, which was accomplished by digging about sixteen or twenty inches square out of the centre of each space, leaving a hard broad border of undisturbed earth, surrounding the hole formed. The earth removed by the operation being arranged on the one side of the hole, formed banks which presented parallel lines of newly turned earth, resting on a hard and unbroken base, and between these lines were the newly formed holes, separated from each other by a bar of undisturbed soil, called the "distance" or "cross-hole bank," which was covered with loose soil, by farther deepening the cane-hole at a subsequent operation, called "cross-holing." This operation entirely removed the surface soil from the hole, so that the hard unbroken subsoil was exposed at the bottom; the surface of the field, when finished, presenting the appearance of a chess-board.

Although the earth was but imperfectly broken up by this process, it was a very laborious one, particularly in stiff soils, and where the roots of the recently cut canes interlaced the earth in all directions. In wet weather, also, the earth adhering to, and clogging the hoes in a very troublesome manner, they required continual scraping, which con-

sumed considerable time, and in dry weather the ground was so exceedingly tough and hard, from never having been perfectly tilled, that very little progress could be made. In general each person would dig from fifty to one hundred cane-holes in a day, although I have seen much more pretended to be done by task-work, but in such cases very imperfectly, the earth being merely scratched into the form of the cane-hole.

The manure, partly made up in pens in the fields, to which it was to be applied, and partly carted from the homestead, and deposited in the intervals between the fields, was usually distributed with baskets, and placed on the spaces left between the holes before cross-holing, the mould from this last operation serving to cover the manure. Sometimes, however, it was thrown into the hole after cross-holing, and lightly covered with earth, till the time approached for planting, when it was dug out and drawn on the bank, or by the side of it.

It generally happened that only a portion of the manure for the crop was made up in time to be applied before the planting of the canes, indeed some Planters rather preferred its application during the growth of the plant, in which case it was carried in baskets and applied round the bunches of the growing canes, during temporary cessations, or after the close of the sugar making season.

The earlier the operation of digging the cane-holes could be performed, the more creditable to the judgment and exertion of the Planter, although this depended, in some de-

gree, on the period of the crop being finished, on the time occupied in preparing land for planting provisions for the support of the slaves, or for sale, and, since the abolition of slavery, in a very great measure on the number of labourers who could be procured.

From the completion of the operation of "holing," till the canes completely covered the surface, constant weeding was required, and large gangs were continually employed. No other method of weeding than hand-hoeing was possible, from the peculiar formation of the angular holes and banks. In fact, the whole system, from the breaking up of the first clod of earth, to the rolling of the hogshhead of sugar into the waggon, appeared to have been expressly contrived for employing the greatest possible amount of human labour. The large amount of capital, therefore, required for the purchase and support of slaves, or the hiring of free labourers, rendered sugar planting, except under peculiarly favourable circumstances, very far from being so remunerative as is generally supposed. In evidence of this, it will suffice to give the following extract from a work published in 1768, a period generally supposed to be the most flourishing in the page of the Planters' history, and which is always referred to as the "palmy days" of the West Indies, &c. &c.

The work to which I have alluded is entitled:—"A Short History of Barbadoes, from its settlement to the year 1767," and I quote a portion of it copied into the "Barbadoes Agricultural Reporter" of June, 1847.—

“ The plantations of Barbadoes, oppressed by taxes, impoverished by mismanagement, and loaded by the great and necessary expenses of their management, yield not now the profits they formerly afforded, notwithstanding the high estimation Europeans may set upon West India estates, yet it is an indisputable fact, that the landed interest of Barbadoes, (that is, throughout the whole island,) does not clear, *communibus annis*, four *per cent.*, estimating the principal at what land usually sells for. The destruction of the woods of that island, though it renders the country more healthful, hath decreased the quantity of rain, and hath been thereby detrimental to the Planters.

* * * To bear up against so many discouragements, the utmost skill ought to be exerted in adjusting the business of an estate, and though it is true that the want of seasonable weather is sufficient to baffle the greatest abilities of the Planter, yet it is equally true, that the failure of these estates proceeds very frequently from unskilful management, so that when some estates that are well attended to yield a very profitable income, others again, afford no profit. Indeed it may be said, with justice and propriety, that an estate as often fails from the unskilfulness of the proprietor, in not maintaining a full quantity of stock upon it, as from the unskilfulness of the steward, or manager. For the former, however, some reasonable excuses may be made, as the want of credit, (a circumstance always destructive to the good condition of a West India Estate,) or the want of opportunity to purchase

stock; but for the latter, no just apology whatever can be offered. Thus, notwithstanding the uncertainty of profit, the unavoidable expense attending an estate is certain, and is inconceivably great. Suppose, for instance, an estate of only 250 acres; to work this properly, must be maintained upon it, 170 negroes, 100 horned cattle, 12 horses, 40 sheep, 3 tenants, or militia men, suppose with 3 in each family, who support themselves from the profits of the ground allowed them; a steward, or manager, whose annual salary may be from £100 to £150; an under steward, or driver, a distiller, and 2 apprentices, whose salaries together may be £45 per annum; add to these the salaries of a town agent and book-keeper at £15 or £20 each, of an apothecary at £30 or £40, of a farrier at £15 or £20, the commissions of an English agent at $2\frac{1}{2}$ per cent., freight of sugars, taxes, duties, repairs of buildings, and many incidental expenses; nor must we forget the maintenance of the proprietor and his family, with eight or ten servants. From these particulars may be learned the reasonableness of the above assertion—that the landed interest in general does not net 4 per cent. annually.”

CHAPTER II.

ON THE NECESSITY OF ADOPTING A SYSTEM OF CULTIVATION AND MANUFACTURE BASED ON A KNOWLEDGE OF THE NATURE OF THE PLANT AND ITS PRODUCT, WITH A SHORT DESCRIPTION OF THE ANATOMY AND PHYSIOLOGY OF THE CANE.

THE two fundamental principles upon which all attempts at improvement must be based, are:—First, the necessity of reducing the cost of production to its lowest possible limit; and, second, the improvement of the quality of the product by a more rational and scientific method of manufacture. These two propositions are intimately connected with each other, inasmuch as, by using improved methods of manufacture, not only is a finer and more valuable *quality* of sugar produced, but a much greater quantity is procured from the same amount of raw material.

Before proceeding to notice the most economical method of cultivating the sugar cane, I shall give a short description of the anatomy and physiology of the plant, and point out the peculiarities to be observed in its culture.

The sugar cane, *arundo saccharifera*, is a plant of the most simple structure, being one of the graminiferous tribe

of vegetables ; in other words, a gigantic grass. The form of its stem is cylindrical, and it varies in length from six to fifteen feet ; it is usually from one and a-half to two inches in diameter, and it is divided into joints, the length of which vary from three to seven inches. Each joint is composed of a number of small hexagonal tubes, which lie parallel to each other and to the axis of the stem ; these have no communication with each other, and terminate at the spot where the joints are united, at which place they come into contact with a complete network of minute vessels. This vascular labyrinth seems designed both to preserve the communication with the cells in the next joint, to convey and elaborate the nutriment required by the germ or bud which is situate at each of these intersections, and by which the plant is propagated, and to communicate with the leaf which is produced simultaneously with the joint, which it encircles and adheres to until it is matured, and by the agency of which the ligneous fibre, and the cellular and vascular tissues are formed. The points of junction between the joints are marked externally by a dark coloured narrow ring encircling the cane, being the part to which the inferior termination of the leaf had been attached. This cincture is bordered by a row of small circular spots, which produce radicles during germination, and at one portion of its circumference the embryo bud is situated. The position of this bud alternates in successive joints to exactly opposite sides of the stem.

A transverse section of the cane shows the divided longitudinal tubes, presenting a cellular structure, and filled with a transparent fluid. Most of these cells contain a pure solution of sugar, which varies in density with the age of the cane, and the circumstances affecting its growth. There are also sap-vessels containing in solution the elementary substances required for the growth of the plant. These lie parallel to, but have no communication with, the cells containing the sugar, and convey the circulating sap from the roots to the upper extremities of the plant.

The whole of the surface of the stem is coated with a thin siliceous crust or glaze, on portions of which, particularly near the union of the joints, and in some varieties of canes more than others, there is formed a small quantity of a kind of wax, known as *cerosie* or *cerosine*.

It must be borne in mind that no uncrystallizable sugar, glucose, or melasses, pre-exists in the cane, the whole of the sugar being crystallizable, and of the variety known to the chemist as *cane sugar*.

The process by which the sugar is elaborated and deposited in the cells of the plant, is one of those inscrutable mysteries of nature which have hitherto baffled the researches of scientific men; but its composition, and the purpose for which it exists in the cane, are clearly understood, being evidently intended to yield material for the progressive development of the plant during its growth, as when the cane is growing rapidly, its juice contains but little sugar, that substance being required as fast as it is

secreted, but when the growth becomes slower as the plant matures, the juice increases in sweetness until it arrives at its maximum density.

Cane sugar is an organic substance, being one of the well-known non-azotised proximate principles of vegetables. It is composed of carbon, oxygen, and hydrogen, the two last elements existing in the proportions which constitute water; therefore it is said to be composed of carbon and the elements of water, in the proportion of carbon 12 atoms, and the elements of water 11 atoms. When deprived of 1 atom of water, (with which it unites as with a base,) sugar becomes anhydrous, and is then composed of carbon 12, and the elements of water 10, but it never exists naturally in this form.

These facts prove, that although portions of the inorganic particles of the soil are abstracted by the plant for the purpose of building up its structure, they form no part of the sugar which is secreted by it, a circumstance which forms a remarkable and distinctive feature in that branch of agricultural industry, which has for its object the cultivation of the sugar cane.

The sugar cane is found growing in all intertropical countries, and it is cultivated extensively both in the East and West Indies. In this treatise, in describing the methods best adapted for producing the plant most abundantly and economically, and the most perfect and effective manner of converting its juices into crystallized sugar, I shall confine my remarks entirely to

the latter region, as that with which I am practically acquainted.

There are many varieties of the sugar cane, but although they differ in size, colour, and productiveness, they are identical in their organization and structure, and the same methods of culture and manufacture apply equally to all.*

Until the beginning of the present century, the variety commonly known as the *Creole cane*, originally brought from Madeira, was universally cultivated in the West Indies; but since the introduction of the *Bourbon* and *Otaheite*, which closely resemble each other, and which are vastly superior, the *Creole* has almost entirely disappeared. Of these, the *Bourbon* is now most generally cultivated, and, when grown under favourable circumstances, and where the necessary attention and skill are bestowed upon its culture, it is as hardy and productive a plant as the most sanguine agriculturist could desire.

The cane is propagated by cuttings, which grow very readily, the part used for that purpose being the upper termination of the stem, which includes a series of short, semiformed joints, each of which is furnished with an "eye" or bud. This portion of the cane, not being matured, contains very little saccharine matter, so that no loss of sugar occurs by using it for plants; but every joint

* Full and elaborate descriptions of the different varieties of sugar canes are given in "Porter's Work on the Nature and Properties of the Sugar Cane," and in "Wray's Practical Sugar Planter."

of the stem is a perfect plant, and will grow readily, and certainly.

Having thus glanced at the anatomy and nature of the cane, and the simple composition of sugar, I shall endeavour to point out the wide difference which exists between its cultivation and that of any other kind of farming, and how much more simple and satisfactory the operations of the Planter would become, was this circumstance fully understood and acted on.

Every cultivated plant deprives the earth in which it is grown, of some portion of its constituent parts, which must be restored, or the soil will become exhausted, and no longer able to produce the plant for want of materials to build up its structure. This is a fact known to all farmers, and has been strikingly exemplified in the cultivation of tobacco; large tracts of land in America, formerly of exceeding fertility, having been rendered sterile, by being incessantly cropped with that plant. The skilful farmer, by a judicious rotation of crops, which differ in their composition, taking care to restore in due order the substances carried off by them, and by exposure of the soil to atmospheric influences by repeated ploughing, giving time and facility for fresh portions of the required substances to disintegrate and become available for the sustenance of plants, is enabled not only to keep his land in continued fertility, but to increase its natural capabilities, and to render the tillage of it easier and more economical.

A knowledge of these circumstances, and a skilful

adaptation of them to any locality, constitutes the science of agriculture—a science which calls forth a very great degree of mental exertion for its acquirement, as a thorough acquaintance with its principles and practice, demands a knowledge of chemistry, geology, botany, meteorology, zoology, and mechanics; and, moreover, requires more than any other branch of industry, patience, research, observation, and untiring zeal.

The agriculture of temperate regions, whatever variety it may assume, causes a certain exhaustion of the soil. The cultivation of the cereals, particularly wheat, produces this effect most speedily, large portions of the elements of fertility being carried off in the grain. Even breeding and dairy farms gradually suffer from the same cause, the bodies of the animals in the one case, and the products of the dairy in the other, abounding in mineral salts. In every case the attention of the farmer ought to be directed to the nature of the substances withdrawn from the soil, and the most economical method of restoring them.

In the ancient practice of agriculture, these facts were imperfectly understood, or totally lost sight of, and the empirical methods pursued were often unsatisfactory, and at best uncertain; but from the recent labours of Davy, Liebig, Shier, Johnston, &c., these uncertainties have been removed, and the science reduced to certain rules, which being based upon natural laws, are infallible, and capable of adaptation to any circumstances.

I have been led to make these remarks in order to show

more clearly the advantage which the Planter possesses over the farmer of temperate countries, in the simple arrangements to which his agricultural practice may be reduced. I mentioned that sugar contains none of the elements of fertility of which the soil has been deprived by the plant. It is therefore obvious, that if, after extracting the sugar, the Planter returns to the earth the megass from the mill, and the refuse from the distillery, the soil will not in any respect be deteriorated or impoverished, but that crop after crop may be reaped; and provided the necessary tillage be afforded, it will rather be improved than injured by this apparently ceaseless drain. It is important therefore for the Planter to bear in mind, that although he cannot too early adopt the mechanical inventions which science and ingenuity have introduced into the agricultural practice of the mother country for economizing labour, and improving the texture of the soil, yet if he bases his operations on a knowledge of the facts above alluded to, he is free from all the anxiety and expense attendant on the production and application of manures.

At present it is true that so long as the megass is used for fuel in the manufacturing process, it is impossible to adopt this system of cultivation. But this objection can be readily obviated, by the substitution of coal as fuel; and when the many and serious imperfections of the established method of sugar manufacture, and the superiority of coal in furnaces of improved construction are considered, as well as the benefit which must accrue from the operation of

the economical and rational system of agriculture proposed, it is scarcely possible to doubt but that its adoption will eventually become general, and that its immense and evident advantages will outweigh every argument which can be raised against it, and overcome the opposition which, in common with all innovations upon established habit, it is likely to experience.

CHAPTER III.

THE METHOD OF CULTIVATION BEST ADAPTED TO THE WEST INDIES,
DEDUCED FROM THE RESULTS OF SUCCESSFUL PRACTICE IN VARIOUS
ISLANDS—REFUTATION OF THE ARGUMENTS ADVANCED AGAINST IT
BY THE ADVOCATES OF THE EXPENSIVE AND INEFFICIENT SYSTEM
USUALLY PRACTISED.

THE first and great object to be attended to in the cultivation of the cane is, the reduction of expenditure; and experience has shown, that all attempts to bring this about by coalitions to reduce wages have been abortive. It is true, wages have recently fallen to about one-half of the usual standard, but this is occasioned by the recent change of duties in favour of slave-grown sugar, and would not continue were brighter prospects opening, from the fact that the demand for labour would then greatly exceed the supply. The only way, therefore, to reduce expenditure, is to adopt such a system of cultivation as shall require few hands, and by such means the supply will become equal to the demand, and then there can never occur the unnatural position of the servant dictating to his employer.

Experience has shown, that all the preparation required

for planting the cane, can be performed better with the plough than with the hoe, and that there is no necessity for employing any labourers in the process, except the persons required to manage the ploughs. The weeding also which is required between the rows of canes can be performed by the horse-hoe or cultivator, which is easily drawn by a horse or a stout mule, and only requires one person to manage it.

By adopting this course the Planter can at once dispense with his gangs of holers, cross-holers, and the greater part of his weeders, so that he will have an abundance of labourers at moderate wages, for those operations in which they are necessary, and thus be enabled to secure the only advantage which the proprietor of slaves possesses over the employer of free-labourers, *a continuity of labour*, which, for the process of manufacture to be correctly accomplished, is indispensable. This will avoid the necessity for expending money, in the meantime, in immigration, as the supply of labourers in the British West Indies is quite sufficient, if their labour be judiciously applied, to keep in cultivation all the estates which were cultivated during the time of slavery.*

When the prejudices of the Planters were so far overcome as to admit the use of the plough at all, which was only accomplished by the great perseverance of the

* Of course, these remarks on immigration do not apply to such Colonies as Trinidad, which have never been more than partially settled, and where, as new land is taken up, an increase of population is required.

spirited persons who introduced it, it was still thought indispensable to go through the form of digging cane-holes, and cross-holing afterwards, which was afterwards modified by ploughing banks and trenches at the required distances, and then forming cane-holes in the trenches by the operation of cross-holing. No one thought it possible that canes could grow in any other way than in the cane-hole which they had been accustomed to; and various reasons were brought forward in support of the cane-hole system.

The first, and most important, was, that unless the earth was disposed in that form, it would be washed away by the heavy rains, particularly on slopes. This is an erroneous idea, as the earth is washed away just as readily when reduced to that form, as if left flat, and, indeed much more so, than if deeply ploughed and with a plain surface. The hill-sides of England are not dug into holes, yet the plough is used unsparingly on them, and we hear no complaints of their washing away. But the banks of the cane-holes are continually giving way, from the weight of water in the holes in heavy rains, and the finest portions of the mould and manure are carried away in rivulets in all directions.

Another reason given is, that the roots of the cane have a tendency to grow upwards to the surface, and that it is necessary to plant it at the bottom of a deep hole, to allow it to follow its bent, by throwing its roots upwards to the top of the bank; and this is attempted to be

proved, by showing the stool of a cane, *grown in a cane-hole*, with its roots, after radiating outwards, all curving upwards at the extremities. This reasoning is very simply answered by the fact, that the roots of the cane, or of any other plant, *must* go in search of the nutriment upon which the plant subsists, and if the cane plant is placed at the bottom of a deep hole, on a hard and barren subsoil, and all the substances which are to support its existence are piled around upon a high bank, its roots have no alternative but to grow upwards in search of the food which they can only find there. Let any one who is unconvinced of this, plant canes, as I have done, in deeply ploughed and carefully tilled land, with a plain surface, and they will find that *no* roots grow upwards, but that one portion of the roots extend laterally to what such persons would consider an incredible distance, and that another portion strike downwards, as far as the nature of the soil will afford them any thing to go in search of. I have followed the roots of a bunch of canes in an alluvial deposit, to a depth of more than four feet, and have traced them to a distance of six feet from the centre of the bunch; and further, in support of this assertion, I quote from one of the Jamaica prize essays, the following passage:—"In digging post holes for a cow pen, in a thrown up cane piece, I have found abundance of strong cane roots, running in all directions, in a stiff, cold clay, two feet perpendicular below the surface. In transplanting some young canes, about six or eight weeks old, I pulled up some with roots

fully three feet long. They must have been much longer, but the fine ends were broken off, by being roughly pulled out of the ground. On mentioning the above circumstances to a friend of mine, he told me that, in confirmation of the circumstances, on one occasion when travelling, he passed a part of a steep bank that had lately fallen from wet weather, and that he could distinctly trace the cane-roots ten feet deep.” *

A further reason given in support of the cane-hole is, that by its peculiar formation all the richest and most soluble portions of the manure are washed down to the centre close to the plant. This is as absurd as either of the foregoing, for as the *extremities* of the roots absorb the nutriment for the plant by their spongioles, and as these roots extend some distance from the plant itself, it is evident that the result of this washing to the centre, is to take the choicest portions of such nutriment out of the reach of the roots. It is like applying food, as you would a blister, to the pit of the stomach, instead of placing it in such a condition that it can be conveyed to the mouth.

The only advantage I ever perceived the cane-hole to possess was, that when the cultivation had been late, and the land was to be planted immediately, a comparatively light shower, from being drained toward the centre of the hole, afforded sufficient moisture to put the plants in, and ensure their springing ; and I have seen it adduced as an

* No. 4 Essay, by W. F. Whitehouse, Esq., St. Mary's.

evidence of the superiority of the cane-hole, that plants would grow in them after a light shower, in general dry weather, when there was not sufficient moisture to produce vegetation in land prepared in any other way. This in itself, however, implies an improper mode of culture, for this superiority only exists when the land has not been tilled at the proper period, but has been recently broken up; for when land, that has been thoroughly ploughed and pulverised, has been once perfectly moistened, which, if attended to at the proper season, it is sure to be, it will retain moisture sufficient to promote the vegetation of the cane plant for a very long period.

The cane requires no cane-hole, nor trench, nor any peculiar formation of the surface of the soil; it is developed in the greatest perfection in deeply ploughed and thoroughly pulverised land, the surface being left in the shape it assumes naturally, and which is not only best adapted for the growth of the plant, but for preventing the removal of the soil by heavy rains. Land, in this state, is also best adapted for the use of those agricultural implements, which are calculated both to improve the texture and fertility of the soil, and to enable the Planter to dispense with much unnecessary and expensive human labour.

When the cultivation is carried on entirely with implements, employing only such hands as are necessary to direct them, there will be an abundant supply of labour at command for all the other wants of the estate; and even

should it be necessary to give higher wages during crop time, for the purpose of ensuring continuous and rapid manufacture, we should only be in the position of the British farmer, who necessarily spends more while reaping his harvest, than at other seasons, and, like him, we should command the services of many who never assist in the labours of agriculture, except at such a juncture, but who would lay aside their various vocations to participate in the additional reward for labour, which it would be to the interest of the Planter then to give. And although, by this system, a large force of labourers would be brought into the market at the close of the manufacturing season, there is no fear of running into the opposite extreme—there need be no want of employment. Those persons who possess, or could procure capital, would be able to improve their estates by draining, making roads, &c., which improvements they cannot now attempt for want of labour; and as these are operations which they can arrange at their own convenience, they would be able to accomplish them at the cheapest rate—a very different matter from the chance of a crop of ripe canes rotting for want of labourers to take them off, because some more fortunate or less scrupulous neighbour is employing them in digging cane-holes, or weeding young canes, operations which, as we have shown, can be better performed with the plough and the hoe harrow.

By pursuing this system not only would the cost of production be immensely reduced, but the crops in time be

increased to double their present amount, and, as a matter of consequence, property would rise to its legitimate value. It is not a plan which requires the investment of capital, but is within the reach of every proprietor of West India property; and were they to insist on their attorneys *not employing a single hoe* in the preparation of the land, but to plant the rows of canes at such a distance apart, as to permit the free use of the horse-hoe or cultivator in weeding the space between, their estates would rapidly recover from the prostration and difficulties induced by want of sufficient labour, and we would hear no more of the necessity for immigration, unless for the necessities of new settlements.

It may be urged by some, that many estates are too hilly to be benefited by this system, as the plough is not adapted for their cultivation. This, undoubtedly, may be the case in a few instances, but the objection, generally, is incorrect, as very few hills on which canes are now cultivated are so steep as not to admit of being tilled by the plough. Here in Scotland, where I write, I see the steep hill-sides ploughed with the greatest ease, and by using a plough adapted for the purpose, of which I have myself proved the efficacy, the difficulty of turning the furrow slices up hill is avoided, as the plough, by a simple contrivance, reverses its mould board at each turn, so as always to throw the furrow slice downwards, and it is so light and easy of draught, that a pair of horses work it with ease in any kind of soil.

CHAPTER IV.

ON THE PLANTING OF CANES—VARIOUS METHODS OF SETTING THE PLANTS—ADVANTAGES OF WIDE PLANTING.

THE next point to be observed is the manner of planting the canes. The plants should be carefully selected; and it would be better to have a nursery or patch of canes, from which to secure good well developed plants, for the early planted pieces, than to use, as is too often the case, small and worthless plants, picked from the worst piece of canes on the estate, and which are generally characterised as being "*good for nothing but plants.*" It is also advantageous to procure plants from canes grown in different localities and soils. This subject, however, although well worthy of being attended to, is not of such paramount importance as the preparation of the land, as almost any plants, when put into good and well-prepared land, will, after the first few sprouts, begin to acquire size and strength, and throw out a sufficient number of fine healthy sprouts from the bottom of the first, and it is these which form the canes which constitute the crop. It is obvious, however, that the better the plant,

and the healthier the first shoots, the more rapidly and perfectly will the succeeding shoots be developed from them.

Canes are planted in a variety of ways. Originally the hoe was the only implement used for that purpose. A chop was made in the bottom of the cane-hole, and the plant being placed in it horizontally, was covered lightly with mould from the sides of the bank, and trodden upon, to prevent the too rapid evaporation of the moisture. It was afterwards deemed expedient by some to use an iron crowbar or drill, which was plunged vertically into the earth, and on withdrawing it, the plant was inserted in the hole thus formed. Others used light pickaxes, by which a hole was made, into which the plant was forced, lying, when planted, at an angle of about 45° above the horizon. All these methods, when carefully performed, answered the purpose. But in land which is well pulverised by deep ploughing and subsoil ploughing, the plant can be pushed in simply with the hand, without any implement being necessary, or, at all events, a small dibble, carried in the basket with the plants, would suffice to remove any trifling obstruction which might exist.

The distance at which the plants should be set apart from each other, has been a subject upon which much difference of opinion has existed. It is not long ago since it was considered necessary to put not less than two plants into the cane-hole, and as many as four and five have been wasted for that purpose. One gentleman, who was eminent as a

Planter in the beginning of the present century, who possessed some fine estates in Barbadoes, and who is still alive, used to put a plant in each corner of the hole, and one in the middle, and regret there was no room for more ! The number of plants has since been decreased, and in some cases the size of the cane-hole increased with much advantage—one plant in a hole, three and a-half or four feet square, being deemed sufficient. About ten years ago an experiment was tried by some enterprising persons of increasing the space between the rows of cane-plants, which proved so successful, that, even without taking into consideration the vast advantage to be derived from the facility afforded for the use of the horse-hoe in weeding, the plan was, in a few years, very extensively adopted in Barbadoes, and St. Kitts, and partially in other places.* The distance most usually adopted, was six feet by four, that is parallel rows, six feet apart, and the plants set four feet from each other on the row. Many, however, planted them farther apart, widening the space between the rows to eight feet, and keeping the plants four feet apart on the row, as before, with what success may be seen from the fact, that a gentleman, well known in Barbadoes, reaped in 1847, from 90 acres of canes, planted eight feet by four, 230 hhds. of sugar. Even with such facts before them, so great is the force of habit and prejudice, that many persons cannot be convinced

* I perceive the author of one of the Jamaica prize essays in 1843, advocating the practice.

of the superiority of wide planting. The space between the rows must always in some degree, be in proportion to the fertility of the soil. In poor soils it may be limited to six feet, and in fertile soils to eight feet. There are instances of persons increasing the distance to ten feet, and in some instances to eight feet square, but these cases are rare.

To those who cannot comprehend how canes can thrive so far apart, it is only necessary that they should witness the bulk and dense appearance of ripe canes, which have been planted in this manner, and their peculiar adaptation for resisting the blighting effects of the frequent droughts, from the length and strength of their roots, for long before they have reached maturity, their roots have penetrated and occupied every portion of the space between the rows, and if the subsoil is naturally good, or made so by draining and subsoil ploughing, they will descend to an astonishing depth in search of moisture and nutriment. This is abundantly evidenced by the success which has followed the experiments of those who have advocated and adopted this method of planting. Yet so powerful is the prejudice in favour of established habits and usages, that numbers of Planters, and I particularly instance Antigua, as being the island with which I have been latterly best acquainted, cannot be brought to see the necessity existing for it, or allow the possibility of its general success, making the most absurd assertions of peculiarity of soil, &c., which they say will not admit of its being successful.

And when in some instances they have been unwillingly compelled by their instructions, to pursue a modified form of it, it has been done so carelessly, and so much against the inclination, that its success has in several instances been rendered abortive. I have found it to answer perfectly well in Antigua, the soil of which island is generally more fertile than that of Barbadoes, and in St. Kitts its success has been most complete and gratifying.

CHAPTER V.

IMPORTANCE OF RETURNING THE MEGASS TO THE SOIL—THE
INJURIOUS EFFECTS OF SEVERE DROUGHT OBIATED BY COVERING
THE SOIL—RATOONING—PROPER SEASON FOR PLANTING.

THE other important point which I would urge on the attention of the Planter, and to which I slightly adverted before, is, to return to the soil every portion of the structure of the cane, both in megass, and in the refuse from the boiling-house and distillery. This will, of course, meet with much opposition from those who are accustomed to consider megass the only fuel adapted for the evaporation of cane-juice. To all, however, who are aware of the superiority of coal as fuel, of the great improvements which can be effected in evaporating vessels, the cheap rate at which coals can be supplied from Great Britain in quantities, and when, moreover, the cost of the coals is saved by the reduction in the expenses of weeding, and of drying the megass for fuel, to say nothing of the expensive process of making and applying manure, now rendered unnecessary, the plan of returning the megass to the soil, must appear calculated to effect an important benefit. It

is also manifestly to the advantage of the shipowner and merchant, as well as to the Planter, by giving an additional employment for shipping, and rendering the trade more profitable, by insuring full cargoes both ways.

There is one advantage, moreover, which the covering of the earth with megass presents, which is of more importance to those Colonies which are liable to have their crops destroyed by severe droughts, than any which I have enumerated, and which must appear clear to all who have considered the subject. The thick covering of megass laid on the spaces between the cane-rows, prevents the great evaporation of moisture from the earth, which takes place in dry seasons. Indeed, the benefit of covering the ground for this purpose is well known to some Planters, who are at the expense of cutting grasses, and carting field trash to cover the surface; and when even so imperfect a covering as this is found useful in averting, in some degree, the evil, it is manifest how great the advantage of such a covering as megass. In fact, there would be a certainty of securing, in any year, however dry, a remunerating crop.

I have long been convinced of the necessity of following out this plan with megass, but have never had an opportunity of doing so except on a small scale, which was, however, quite sufficient to verify its correctness.

A late writer (Mr. Wray) also advocates the returning of the megass to the soil, and using coal for fuel; and, I think it the most valuable suggestion in his book. He

does not seem, however, to be aware of the advantages which it would present, as a shield from the effects of droughts, for he speaks of burying it in the earth, and allowing it to rot, which would be a troublesome as well as a useless operation, because it would as surely resolve itself into its elements, although more slowly, if placed on the surface, as if buried under it.

I remember a remarkable instance of the good effect of covering the banks of cane-holes, in a field pointed out to me on an estate in Barbadoes, which had borne a very large crop of canes in a dry year. The soil of the field was so shallow, that large quantities of stones had been broken up with pickaxes from the bottoms of the cane-holes, and had been disposed upon the banks; and the stone having a sort of schistose fracture, giving flattish slabs, formed a tolerably complete covering for them. This prevented much of the evaporation which would otherwise have taken place; and many jests were current at the time on the peculiarity of the *manure*, as it was jocularly called, and its remarkable effects. This circumstance must be fresh in the recollection of many persons in that island.

It is supposed by some persons, that placing a thick coat of vegetable substances upon the earth, will give shelter to numbers of insects, and so nurse a source of injury to the young sprouts. We do not, however, find that the thick covering of field trash left upon some of our ratoon fields, is productive of this species of injury.

But even should it be found that this does occur, it is easily corrected after taking off the last crop of ratoons, by burning the field trash on the surface, a process which would effectually destroy all insects and their larvæ.

Under the usual system of planting, I have always studiously avoided burning, making it a principal object to accumulate all the vegetable matter possible on the surface. But where the plan for returning the megass to the surface of the soil is adopted, the objection to its being occasionally or periodically practised, would no longer exist.

Another subject which, in an economical point of view, cannot be too strongly advocated, is, that more attention should be paid to ratooning. Good ratoons can only be produced by a deep and early tillage of the land to be planted; and more land should not be broken up than can be *thoroughly* tilled at an *early* period. It is a very common error to grasp at too much, and to do the whole imperfectly. It is much more economical in every way to make a hundred hogsheads of sugar from thirty or forty acres than from sixty or eighty. In fact, the quantity of land planted should not be regulated by the size of the estate, but by the power of stock and implements at command; and the preparation should in all cases be completed at least three months before the time for planting. When this rule is observed, and a thick covering of vegetable matter applied to the surface, good ratoons will be sure to follow, particularly where the rows of canes have

been planted sufficiently apart from each other. I have seen ratoons equal to good plant canes, grown upon land which was previously supposed to be incapable of ratooning; and during the present year, some of the finest and healthiest looking canes, on a particular estate with which I am acquainted, were ratoons, growing in rows seven feet apart, and this after a season of severe and protracted drought.

The proper season for planting varies in different Colonies and localities, but the fault of late planting appears to be rather general. It is better not to plant the bulk of a crop at once, but at intervals, commencing very early, and extending it over a period of about five months, planting a portion every month. This will regulate the season for reaping, and will enable manufacturing operations to be commenced at a proper period, and finished before the rainy season sets in and causes a fresh and injurious growth to commence in the canes.

I could say much on the necessity of paying strict attention to all the more detailed operations in the conducting of an estate, as cutting canes, carting, &c. &c., but I do not intend this as a treatise on management, so much as an elucidation of such a system of cultivation as is within the reach of every proprietor of a sugar estate, a system which, I believe, will at once reduce the cost of production, increase the supply of

labourers, and prevent, to a great extent, the recurrence of so serious a calamity as the loss of a crop by drought. It is scarcely possible, however, in treating of this important subject, to avoid digressing considerably in order to illustrate more fully the advantages of the system proposed.

CHAPTER VI.

ON STOCK AND IMPLEMENTS OF AGRICULTURE.

I NOW proceed to consider the materials, by the use of which so much benefit may be produced,—stock and implements of agriculture.

The *number* of cattle on most estates exceeds their requirements, but their *strength* is generally quite inadequate to what is expected of them, even for the usual carting operations. This arises from the little care bestowed either in feeding or lodging them. They are left, when not at work during the day, to ramble about upon some bare and arid pasture, or “hungry hill-side,” to pick up a miserable subsistence among the roots of the coarse herbage, while, from the carelessness of the herdsmen, they are continually destroying the growing crops in passing and repassing. And at night they are turned into some comfortless pen on a bleak field, or exposed yard, sometimes up to their knees in filth, and exposed to every vicissitude of weather, often to the pouring of incessant rain; while their food varies from bad to worse, either the green and often tainted tops of the

cane, or the same dried and half-rotten, or a scanty bundle of dry and old grass, which is more than half lost in the surrounding filth. For this reason, we find that eight oxen are often inadequate to do the work which four, in good condition and well fed, could do with ease. This state of things is too generally the case, and the mortality which ensues is clearly evident by the heavy item in the annual expenses of the estate, for the supply of this deficiency. Mr. Wray, in speaking of the mortality among the cattle on estates in Jamaica, says, "These little circumstances may seem very trivial, but indeed they are not so, they serve to swell the number of reasons why Jamaica estates do not pay, and account for the heavy losses sustained in the numerous cattle that die off, or rather that are ignorantly killed every year. Is it not to be expected that cattle so abused will die? Is it not indeed a matter of surprise, that any of them survive such shocking treatment? It really is. And when we consider that good young oxen or steers cost in Jamaica from £10 to £16 sterling each, we cannot fail to perceive, that every possible reason is in favour of a proper selection and management of cattle.

* * * But this is by no means the plan pursued in Jamaica. On almost every estate in the island, the cattle may be seen lying at nights, all the year round, in open and exposed cattle-pens, often knee-deep in muck and mire; at one season of the year bloated with green grass, at another half-starved, miserable, and swarming with ticks—hard worked by day, and wretchedly fed at night.

On no estate have I ever seen good, clean, well covered-in stalls, in which a steer might be tied up and fed. Neither have I ever seen guinea-grass hay made and stacked for the working cattle of an estate, that they might become firm in flesh, and capable of great and long continued exertion. Far from all this, I have generally remarked a total disregard for their preservation, amounting to a shameful sacrifice of property. Amongst the many, I will instance a property I was once intimately acquainted with, on the north side of Jamaica, of about 750 acres, and then making 150 hhds. (of 1800 lbs. each) of sugar. * * * This property had 250 head of horned cattle, worth, as nearly as possible, £8 a head—£2000 sterling—about 40 mules, value about £20 each—£800—in all £2800 sterling for cattle alone, which one would be apt to suppose an enormous sum, yet this estate was every year supplied with fresh cattle to supply losses by death. * * * We know that the average working period of a steer or heifer in Jamaica, under favourable circumstances, is 10 years, but when a little extra care has been bestowed upon them, we may safely reckon on 15 years, whilst a mule, with common care, will work for 20, 30, and even 40 years. I have had four mules varying in age from 45 to 48 years each, as proved by most undoubted evidence, and all of them at that age taking their regular spells in turn.”—*Wray's Practical Planter*.

There are some persons who deserve great credit for the care which they bestow upon their stock, and there are

instances of estates, upon which cattle never require to be purchased. The proprietors reap the benefit of such wise conduct, not only in being saved this great and increasing outlay, but also in the greater amount of work performed by their cattle. But these are, unfortunately, exceptions to the general rule, and the necessity for the proper care of the stock of an estate, cannot therefore be too strongly inculcated. They are the first and most indispensable requisite of the agriculturist, and without them he can do nothing. Every beast is a separate engine of force, which must be separately attended to, and all its wants carefully supplied; and the first and most important building on the estate, is the one in which the stock are to be lodged. There is no occasion for having a greater number of stock than the extent of the cultivation requires; but it will be the most economical, as well as the most effective system, to house them entirely, giving each animal *its separate stall*, well ventilated and kept free from all filth—the stalls being so arranged that all the excrements and litter can be swept into a common receptacle, sunk below the level, which can be performed by the persons at present employed to saunter about with the cattle on the so-called pastures. In these stalls the cattle should be fed at stated times, and an ample and regular supply of food provided, by planting guinea or para-grass. Moreover, all estates should produce sufficient grain for the support of their working stock, and so save the necessity of purchasing.

The Psalmist, in praying for the prosperity of his people,

asks emphatically, among other blessings, "that our oxen may be strong to labour, that there be no decay."

Oxen are best adapted for ploughing stiff lands, keeping a heavier and steadier strain than horses or mules, but the latter answer better for weeding, carting, and all the lighter work, as being more rapidly and easily managed, and not trampling the cultivated ground so much.

All carts and waggons should be of as light a construction as is consistent with strength; and where they are intended for carting substances over the finished preparations, the wheels should be made very broad and light, to prevent them sinking into the land. Indeed, by a little ingenuity in the construction of light carts, for carrying manure or megass into the fields of young canes, most of the manual labour can be saved, as the carts, if properly constructed, can be driven through the young sprouts without doing them any injury. Care should be taken that all the harness is well fitted to each animal. The portions which press forcibly on the body, as they often become very hard with a little use, should always be carefully stuffed and soft; and the yokes and collars used for cattle should be light and well padded.

The various ploughs in use have each their admirers, and their adaptation varies with soil and locality. Wilkie's has been most used, but Ransome's and Jefferies's are excellent, and there are many light ploughs of American construction, which, in light soils, do a great deal of work, being of very easy draught. The hill-side plough, to which I formerly

alluded, was a light American one, and I found it to answer the purpose admirably. The lightest and best subsoil plough which I have seen is "Read's subsoil pulveriser," by Stratton of Bristol. I have used both it and "Smith" of Deanston's subsoil plough, but the latter requires a great strength of cattle to draw it, and although, when understood, it is easily handled, yet its weight and resistance render it much less generally serviceable than the first named, which performs its work admirably and without any undue exertion of the stock.* Of other agricultural implements, as "hoe-harrows," "cultivators," &c., their superiority will always be in proportion to the *simplicity* of their construction, as I have always found those which are least complicated, the most efficient.

* To all who desire to obtain information on the subject of ploughing, the effect produced by ploughs of various construction, the care of stock, and all other subjects connected with modern agriculture, I would recommend the perusal of "Stephens's Book of the Farm," as the most complete and valuable work on agriculture ever published.

CHAPTER VII.

RECAPITULATION—NECESSITY OF REFORM IN THE METHODS EMPLOYED FOR THE PRODUCTION OF SUGAR—IMPORTANCE OF A WISE LEGISLATION WITH REGARD TO THE WELFARE OF THE WEST INDIAN COLONIES—THEIR IMPORTANCE AS SUGAR PRODUCING COUNTRIES.

IN the foregoing pages I have principally discussed the culture of the sugar cane, and the most profitable method of conducting the agricultural operations of a sugar estate, with a view to diminish the cost of production, and to increase the crops, by adopting such a system as may not impoverish the soil, and also to obviate, in a great measure, the losses occasionally sustained in seasons of drought.

The remarks which I have made are not based upon theoretical deductions, but are facts, the correctness of which has been verified by experience, and will be admitted by every one who is practically acquainted with the matters under discussion. If these facts and conclusions are duly recognised and acted upon, West Indian Planters cannot fail to effect an immediate and salutary change in their position and prospects. The proposed improvements are not liable to the objection to which many

schemes for benefiting the Colonies are open to ; the substitution of the plough for hand-hoeing, and the greater care of the cattle, *require no fresh investment of capital*. Secondly, the results are not problematical but certain. Thirdly, these improvements can be adopted by every individual proprietor, independently of the co-operation of his neighbours. Fourthly, they are attainable without the assistance of Government. Fifthly, the consequence of such improvements will be to develop an abundant labouring population, in places which at present are supposed to require the aid of immigration. And, sixthly, the system I have indicated will tend to keep the rate of wages at a regular and moderate standard, and to render the peasantry orderly, civil, and industrious—qualities which have rarely been developed during the last fifteen years.

In the succeeding portion of this work, I shall endeavour to show clearly the imperfections in the various stages of the process of manufacture, as at present practised ; to indicate the losses sustained in each of these stages ; and to point out such methods as science and successful practice have demonstrated to be effectual in preventing such losses, and in rendering the product more valuable to the manufacturer.

This portion of my subject will necessarily be distinct from the former, as requiring the investment of capital in effecting certain improvements in the machinery and apparatus employed. I hope to demonstrate satisfactorily,

that such outlay will be no rash speculation, but that the advantages to be derived from it are so certain and considerable, that the value of the saccharine matter at present lost in one year by imperfect manufacture, would in most instances be sufficient to cover the required outlay.

I am aware that at present many West Indian proprietors are in such embarrassed circumstances, that they would find it difficult to make the requisite changes, being unable to command the necessary outlay. But there is reason to hope, that if the real state of matters in the West Indies were fairly brought before the British Parliament, the necessary aid would not be refused. Aid has been liberally granted for the improvement of estates in Great Britain and Ireland, from which no such prospects of ample and rapid returns can be expected as in the case of sugar estates in general. We are also encouraged to make such application, from the fact of the British public beginning to perceive that great and uncalled for sacrifices of West Indian property have been made *unnecessarily*, and without the attainment of the desired object, or indeed of any equivalent. A loan for a short term of years would be sufficient to render these Colonies flourishing, and quite adequate to the production of an abundance of good and cheap sugar for the consumption of this country. Precautions can easily be adopted to prevent misapplication of funds in aid. The investments might even be rendered safe and popular stock in the English money market, by a guarantee similar to that given by Government in favour

of the loans granted to Canada for public works, (canals, &c.,) and in return for the guarantee by the Imperial Government, the Colonial Legislatures might enact a *preferential* claim or liability on all estates to which Government grants or loans might be extended. All this is practicable without any injustice to claims already existing, when the very object would be to create funds for the liquidation of prior obligations.

The Planters must also remember that they have not only to contend with strangers, but with one another; and those who do not bestir themselves to effect the improvements which are so obvious, and so imperatively required, will be distanced, undersold, and ruined by their more enterprising brethren.

There is no doubt that our West Indian possessions contain the elements of prosperity in an eminent degree. Under a proper system of agriculture, their fertility is inexhaustible; their geographical position with regard to the markets of Europe is all that could be wished for; and the increasing demands of North America will, for generations to come, render the West India islands, and the adjacent portions of the continent, in whatever hands they may happen to be, possessions of first rate importance, and sources of boundless production and wealth.

Some alarm has been expressed by persons interested in the West Indies in consequence of the rapidly increasing production of beet-root sugar on the continent of Europe; but when we reflect upon the inferiority of the beet in

the comparative quantity of sugar it contains, being only half of that afforded by the cane, the complex nature of its juices, and the expensive methods necessary for obtaining its sugar, it is evident that on equal terms, the production of sugar from the beet stands no chance of successful competition with the sugar cane.

The competition of the Eastern hemisphere need never be dreaded, because the rude and imperfect process of manufacture, the greater difficulty and expense of inland transit, and of ocean freight, will always be obstacles to successful competition with the West Indies; not to mention, that the dense population of Asia is sufficient to consume all the sugar produced there.

The importance of a wise legislation with regard to our West Indian Colonies, is therefore an object of primary importance.

PART SECOND.

ON THE MANUFACTURE OF SUGAR.

CHAPTER I.

LOSSES SUSTAINED BY IMPERFECT MANUFACTURE—COMPOSITION OF THE CANE AND ITS JUICE—STATE IN WHICH SUGAR EXISTS IN THE CANE.

I COME now to the second portion of my subject—the necessity for adopting a more correct process of sugar manufacture, the method commonly practised being, as we have stated, very imperfect, not only causing a vast loss of saccharine matter, but making the largest portion of that which is brought to the market of so inferior a quality as to be unremunerative.

It is for the mutual interest of planter and merchant that an improvement should be effected, because the first will derive a larger revenue from the increased quantity and value of his sugar, and the latter will not only find employment for a greater amount of shipping, but, as under proper management, there would be no loss incurred by

drainage on the voyage, and as the present freight is charged upon the quantity of sugar *landed* from the vessel, it is evident that he will realize his freight upon the twelve per cent. of sugar, which, from the present faulty mode of manufacture is lost by drainage in the ship's hold.

It is true that in improving the manufacturing process, capital must be embarked to make the necessary alterations in the machinery and apparatus, and to effect some changes in the buildings in which these operations are conducted; but it is obviously the interest of those who can command the means to lose no time in effecting such changes, as the benefit to be derived from such a course is so great, that the increased and improved production of a single year will go far to repay the expenses incurred; and even in the case of Planters who cannot command sufficient capital to purchase new machinery, if a system of manufacture were adopted based on a knowledge of the nature and properties of the substances to be operated upon, the quality of their sugars would be greatly improved.

It is difficult to conceive any thing more rude than the usual method of sugar-boiling; but it is not surprising that no improvement should have taken place in the process, when we reflect that the persons who direct it are ignorant of the nature of the substances contained in the cane-juice, and what knowledge they have of the manufacture has not been obtained by employing their reasoning faculties, but simply by watching an empirical process until they become acquainted with its details—a process

which the negro sugar-boilers, by longer habit, become better acquainted with than those who superintend them. In fact, the difference in quality of most of the sugar at present made, depends more upon the care and attention of the head boiler than on any superior knowledge possessed by the manager.

Both in France and England, attention has been drawn to the necessity of improvement in this process; and men of science and zeal have been busily investigating the subject. Dr. Evans, especially, has become eminent, and his valuable work on sugar manufacture has done much to diffuse information on the subject. Dr. Mitchell of Trinidad has also been zealously engaged, and his researches and information are of the most valuable description, not only on the proper treatment of cane-juice when obtained, but also on the method of procuring the largest possible quantity from the canes by crushing—an operation very imperfectly performed by the mills commonly used.

I shall take the liberty of quoting in the following pages, some valuable suggestions from the works of these gentlemen, which are very far from being so generally known as they ought to be, and I shall consider the subject under the following heads:—

First,—The nature of the cane, and the state in which the sugar naturally exists in it.

Second,—The manner of procuring its juice in the greatest abundance by the ordinary method of crushing.

Third,—The method for procuring the largest quantity and purest quality of sugar from the expressed juice, with a description of the imperfect process which has hitherto been employed, and of which M. Michiel in a recent pamphlet justly says, “it has little, if at all, improved since the days of Marco Paolo, six centuries ago.”

The cane, when ripe, contains, according to Peligot and other analysts, about 18 per cent. of sugar, 10 per cent. of ligneous matter, and 72 per cent. of water, with a small amount of impurities, varying in quantity with the nature of the soil, or the circumstances under which the canes are grown. These impurities, although existing in minute quantities, exert a very deleterious influence upon the sugar during the process of manufacture. They consist chiefly of saline matter, and of a highly deliquescent substance, the composition of which does not appear to be known, and which Hervey simply designates “*matière deliquescente*.” The proportions of sugar and water differ according to the ripeness and perfection of the cane, some canes containing much more than the 18 per cent. of sugar assumed as the usual quantity, the amount of water decreasing in the same proportion—old hard ratoons also contain more ligneous matter than soft and juicy canes.

An erroneous idea seems to prevail, that a portion of the sugar contained in the cane exists in a state of ready formed crystals; and I am the more particular in noticing this error, as I perceive that Mr. Wray, in the “*Practical Sugar Planter*,” not only asserts that this is the case,

but proposes a very expensive addition to the sugar mill, for the purpose of saturating the megass with hot water, and reexpressing it between additional rollers, in order to obtain the substance of these imaginary crystals. He says, pages 298-9,—“The saturation of the expressed canes with hot water or steam has the effect of rendering soluble, matter which may be resident in them in a concrete form, so that when they pass through the second set of rollers they part with this desirable matter; whereas, if not so saturated, mere pressure, though carried to the greatest possible extent, cannot effect this important object. It has often been proved that canes contain a far larger percentage of crystallizable matter than planters, even with the best mills, succeed in obtaining from them. This has been pronounced by the most intelligent and skilful chemists, to be in a great degree owing to the fact of the cane depositing in its cells sugar in a concrete form, perhaps I should say crystalline form, as the microscope discovers true crystals deposited in the cells, which cannot be obtained by mere pressure, because it is not in solution. Pressure may deprive the cane of its juice, and that juice may contain all the sugar, or crystallizable matter, existing in it in a soluble form; but it is evident that whatever portion of it may have taken a concrete form, will remain adhering to the cellular tissue, until it is brought into a state of solution, when it may undoubtedly be obtained by a farther pressure. It is also quite clear, that this deposit of concrete matter takes place to a much greater

extent in fine, rich, and fully matured canes, than in any others, which assures us of this singular fact, that the more rich and ripe our canes are at the time of cutting, and the more dry the weather has been, the greater is the deposit of saccharine crystallizable matter, in a concrete form, and consequently the greater is our loss when means are not used to secure this rich store. With this great fact before us, it becomes the planter's duty to inquire, what means he can employ to prevent so serious a loss to his estate. Nothing is more natural and necessary than such a question, and it can be easily and satisfactorily answered. The appliance of a liberal quantum of hot water to the crushed cane, whilst passing along the band from one set of rollers to the other, will be found a simple and sufficiently efficacious means of obtaining the desired object," &c. &c.

Mr. Thomas Burnell also, in a letter addressed to Lord Elgin, published with the Jamaica Prize Essays, remarks on the same subject,—“That sugar exists in a pure form in the cane, is evident; as a microscopic inspection of a thin section will present the perfectly formed crystals, filling the angles and coating the sides of the hexagonal cells, according to its state of maturity, with a column of limpid fluid in the centre, which gradually diminishes in volume as the cane ripens, and the crystals form from this mother-water,” &c. &c.

I have seen remarks, having the same tendency, from various other sources; and I have observed, that all manu-

facturers of machinery for crushing canes, with whom I have communicated, or whose opinions have been published, appear to be impressed with this fallacy. It is necessary that all persons engaged in the manufacture of sugar, should be disabused of this idea, as opposed both to reason and evidence; because, assuming that the cane contains two parts of sugar, dissolved in seven parts of water, which is about the proportions in which it is proved they exist in ripe canes, and knowing that crystals of sugar *are soluble in half their weight of cold water*, it is impossible that sugar can exist in the crystalline form, when in contact with *three and a-half* times its weight of water, an amount sufficient to dissolve seven times the quantity of crystallized sugar. This can be readily proved, by any inquirer, making the simple experiment with refined sugar and water.

Osmin Hervey says,—“Moreover, a liquor *never* crystallizes from its mother-water, without leaving it at the point of saturation; and this explains why M. Avequin obtained so much melasses, or mother-water, from crystallised sugar, whilst M. Plagne, on crystallising the mother-water two or three times, obtained almost the whole mass crystallised, a circumstance inseparable from Colonial manufacture. What we advance is sanctioned by practice. The finest clayed sugar is used in preparing royal sugar. The syrup which is boiled in the vacuum pan may be considered as solution of sugar almost pure, yet at the first crystallization only 50 per cent. of the

sugar is obtained, and the quantity cannot be increased without caramelising a portion. According to M. Duban-faut, this depends on the fact, that one part of boiling water can only dissolve five parts of sugar, and abandons three on cooling, while one part of cold water dissolves two parts of sugar; and this constitutes the mother-water or melasses."

We see from the above, that if the cane contained 60 per cent. of sugar, and only 30 per cent. of water, instead of 18 per cent. of sugar, and 72 per cent. of water, the sugar would still be in a liquid, and not in a crystalline form. And we have the direct evidence of Dr. Davy, who, during his late residence in the West Indies, made the experiment in the most careful manner. Dr. D. says, "It may be well in beginning, to consider what are the contents of the ripe sugar cane. A fresh transverse section of it, a thin slice, is found to be diaphonous, very like a thin slice of an apple, or a turnip, and homogeneous, as seen by the naked eye. Under the microscope it exhibits a cellular structure, the cells containing a transparent fluid. *There is no appearance of crystals, nor of any opaque matter. If the thin slice be dried, the appearance it presents is altered.* It is no longer homogeneous, as seen by the naked eye, or a common magnifying glass. Little dots of an opaque whitish matter are visible, protruding, as I believe, from the divided longitudinal tubes, and cells are seen surrounding these opaque dots—cells which are transparent, and in which, placed in sunshine, minute glittering crystals are

observable, which, it may be inferred, are crystals of sugar, *formed in consequence of the evaporation of the aqueous part of the cell juice.* These observations seem to prove, that the saccharine matter of the cane exists in it in a state of solution, according to the commonly received opinion. This I mention particularly, because a different inference has been drawn by some inquirers, viz., that the saccharine matter is secreted in the crystalline state, in brief, as crystals of pure sugar, an inference which, it appears to me, is neither probable, *a priori*, on theoretical grounds, considering the strong attraction sugar has for water, nor in agreement with the results of carefully made observations. I may remark, it would be extraordinary indeed if crystals of sugar, a substance which deliquesces in an atmosphere saturated with water, were found to exist in a cellular tissue, so abounding, so saturated with aqueous juice, as is that of the cane. This its powerful attraction for moisture is easily shown, by suspending, wrapped in muslin or thin paper, a piece of refined sugar, in a bottle to be well corked, in which there is a little water, in consequence of which the air included becomes saturated with moisture. In this very damp atmosphere the sugar will be found rapidly to deliquesce, and in a day or two to fall in drops into the water, and to continue so to do till the whole of the solid mass disappears."

I have been thus explicit upon this subject, because it is desirable to prevent the erroneous idea from being entertained, that sugar exists in the cane in a crystalline form,

and so inducing persons to have expensive additions to their machinery, for the purpose of extracting a substance which has no existence. It is easy to perceive how microscopists have fallen into the error of supposing crystals of sugar to exist in the cane, as the moisture dries so rapidly from a thin slice that unless observed *immediately* on being separated, crystals will have formed from its evaporation.

It is perfectly understood that no uncrystallizable sugar or melasses pre-exists in the cane, but that the whole of the 18 or 20 per cent. of sugar existing in it is crystallizable, and is procurable from it by adopting the proper means.

CHAPTER II.

METHOD OF EXTRACTING THE LARGEST POSSIBLE AMOUNT OF JUICE FROM THE CANE—VARIETIES OF CANE MILLS—LOSS OCCASIONED BY IMPERFECT MACHINERY—ADVANTAGES OF STEAM POWER FOR CANE MILLS—DIRECTIONS FOR THE PREVENTION OF ACIDITY AND VISCOUS FERMENTATION IN CANE JUICE.

HAVING examined the state in which sugar exists in the cane, we come now to consider in what manner it can be extracted most abundantly; and on this subject I shall confine myself to the method usually practised of crushing the canes between revolving cylinders; for although other methods have been advocated for extracting the sugar by slicing and affusion, they present difficulties which will probably prevent their ever being brought into practice, especially if the crushing mill be so improved as to extract as much of the juice as it has lately been found capable of doing. The hydraulic press has been proposed and tried but without complete success; and although I understand that a modification of this machine is now being brought into operation, it is not likely to be so effective as the crushing mill; and, moreover, the solid mass into

which it compresses the megass, will be difficult to apply as a manure or covering for the earth, for which, in the form it issues from the common mill, it is admirably adapted. Besides, the common method of grinding is simple, well understood, and free from the complexity of manipulation which the other processes demand; and although the whole of the juice cannot be extracted by any kind of pressure, it is possible, by improved cylinders and care in regulating their motion, to reduce the quantity remaining in the megass to a very small amount. This subject has attracted the attention of the French Colonists for some time, and has lately been thoroughly investigated by Dr. Mitchell of Trinidad, whose energy and perseverance deserve the grateful thanks of every one interested in this subject.

From experiments which have been made, it is certain that the mills commonly in use do not extract more than from 50 to 60 per cent. of the juice of the canes passed through them. Indeed, I may say, from what I have myself observed, that the average return scarcely exceeds 50 per cent. or very little more than half the saccharine matter contained in the canes; which shows what a serious loss is sustained by the defective method of pressure alone; and when to this we add the further loss occasioned by the imperfect process of manufacture, is it to be wondered at, that under the present system of management, sugar estates are unprofitable. M. Daubrée does not in the slightest degree exaggerate the loss accruing by the usual process, when he states the planter's

return, under the most favourable circumstances, upon 18 per cent. sugar contained in the canes as follows:—“8 per cent. left in the megass; and of the 10 per cent. expressed, 5 per cent. passes into cisterns, ship's hold, and warehouses, as melasses, leaving only 5 per cent. to meet expenses.”

This agrees with what every planter of observation must have noticed; for even when canes, after being fully ripe, are ground, giving a juice of a density equal to 12° Beaumé, and containing 22 per cent. of sugar, it requires from 12 to 14 tons of canes to give 1500 gallons of juice, the quantity required to produce a hhd., netting 15 cwt. in the English market, and therefore not yielding to the planter a return of more than 6 per cent. of moist muscovado sugar, and that often of a very inferior quality.

It has been proved that the ruinous loss sustained by the imperfect pressure of the mills in common use, can be reduced, by attending to the proper adjustment of the surfaces of the cylinders, and by decreasing the motion to a regulated rate. The Marquis St. Croix, who tested mills in every possible way, says,—“The effectual power of cane mills is in exact proportion to the slowness of the revolution of the rollers, other things being equal. My mill gave as the result of repeated experiments, 46 per cent., with a speed of 8 revolutions per minute; while at a speed of $2\frac{1}{2}$ revolutions, it gave 70 per cent.”

Dr. Mitchell, in detailing some of his experiments on the same subject, says,—“I tested a windmill in Barbadoes,

which was pointed out by several parties as one of the best, capable of grinding six hhds. of 40 inch truss per day. The velocity was 8 revolutions per minute, diameter under 24 inches, return 45 per cent. In other words, for every 6 hhds. of sugar made, 6 hhds. remained in the megass, and were lost. * * * Woodbrook vertical mill in Trinidad, at a speed of 10 revolutions per minute, gave 35 per cent. of liquor. The best mill I saw in the Leeward Islands, was that of M. Bauscarin in Gaudaloupe. It gave 73 per cent., speed 3 revolutions per minute, diameter 24 inches. On submitting the megass afterwards to a powerful hydraulic press, it yielded 10 per cent. more, making in all 83 out of the 90 per cent. contained in the cane. The hydraulic presses were found too expensive, and therefore discontinued. * * * Had this mill been reduced in speed to 2 or $2\frac{1}{2}$ revolutions per minute, with an increase of one inch in the diameter of the rollers, there can be little doubt that the megass would have been equally laminated, and 80 per cent. obtained, without recourse to the hydraulic press. Every quality required in a mill may thus be secured, by diminishing the velocity, and increasing the length of the rollers, in proportion to the amount of liquor required. The bearings, of course, must be strengthened in the same ratio. The greater the diameter, *ceteris paribus*, the less will the megass be torn."

To show that this is not a theoretical deduction, unsupported by practice; and to prove that the power of mills is not diminished with their speed, but that they are capable

of delivering as much juice in a given time, as mills of more rapid motion could do, Dr. Mitchell says, in a pamphlet published after the above,—“ On the estate of St. Ange, Sinson, (Martinique,) whose establishment presents every applicable modern improvement, a 15 horse engine drives rollers 24 inches in diameter, 3 revolutions per minute, expressing 69 per cent. of juice from ratoons containing much woody fibre, and yielding regularly 900 gallons per hour. Worthy Park (Jamaica) has a water wheel, once of great power, and a steam engine. The former, with 9 horse power of water, drives rollers 24 inches in diameter, and 62 inches long, $2\frac{1}{4}$ to $2\frac{1}{2}$ revolutions per minute, and delivers 800 gallons per hour. A 14 horse condensing engine ($1\frac{1}{2}$ lbs. pressure) turns rollers 24 inches in diameter, and 48 inches long, at $2\frac{1}{4}$ to $2\frac{1}{2}$ revolutions per minute, and delivers 200 gallons per hour. *A mill giving 70 per cent., turns out the megass laminated, not lacerated, when the speed is from $2\frac{1}{4}$ to 3 revolutions per minute, while at double that speed, the mill will not give 60 per cent. and tears the megass to shreds.* Dr. Evans suggests rendering velocity uniform by regular feeding. This may be suitable to small mills, but not to leviathans that gorge from 8 to 10 tons per hour. Machinery of this kind should regulate itself.”

Mills of this improved construction are at present being made in this country by our engineers, but principally for foreigners. In Glasgow especially, this manufacture is carried on to a large extent by Messrs. Neilson & Co., and

by Messrs. M'Onie & Mirrlees. The largest machines which I have seen are those made for Cuba by Messrs. M'Onie & Mirrlees. These gentlemen have now in course of construction a steam mill whose rollers are 32 inches in diameter, and nearly 7 feet in length, with an expansive high pressure engine of fully 60 horse power, the connecting gearing being arranged to regulate the motion at $2\frac{1}{2}$ revolutions per minute. Some idea of the strength of this mill may be formed from the fact, that the wrought iron gudgeon of its upper roller weighs about $2\frac{1}{4}$ tons. During the early part of this year two mills of the same kind and construction, but somewhat smaller, having rollers 6 feet in length by 30 inches in diameter, with corresponding steam power and appurtenances, were sent to Cuba by this house, and last year they sent out one exactly similar. From these mills a return of 72 per cent. of juice is obtained, and one of the last mentioned size is capable of taking off a crop of 2000 tons sugar. The cost of such an engine and mill, with appurtenances, is about £2300. On Mount Bentinck estate, in the island of St. Vincent, a mill made by the same parties, having rollers 4 feet in length by 24 inches in diameter, makes 2 revolutions per minute, and yields 72 per cent. of juice. This mill has now taken off two crops. I saw at the same establishment various mills with their steam engines, from 22 horse power downwards, and all geared to run the rollers with a similar slow motion. One, intended for Montrose estate, Demerara, and which I understand has since been erected there, is a 22 horse

power expansive engine, with rollers 5 feet long and 28 inches in diameter, which make $2\frac{1}{2}$ revolutions per minute, and will give from 2500 to 3000 gallons liquor per hour. This machinery was accompanied by five powerful vessels, which are intended to clarify the whole of the cane juice by the waste steam from the engine, and by boilers which are meant to generate all the steam by the waste heat from the coppers' flues. The cost of such an apparatus, with two batteries of carron pans and all appurtenances, complete, is, I understand, about £2500. A second, of 12 horse power, having an expansive steam engine and gearing to turn the rollers at $2\frac{1}{2}$ revolutions per minute, was intended for "Tulloch" estate, Jamaica, and the others, besides being geared to revolve at the same slow rate, had also, in many cases, the additional apparatus for clarifying by the engine's waste steam, and for generating all the steam by boilers placed at the end of the coppers. These last mentioned improvements, I am informed, have been carried out on a great number of estates by Messrs. M'Onie & Mirrlees, during the last four years, particularly in the island of St. Croix.

It is evident, from what I have stated and quoted, that it is in the power of the planter, by making the requisite alterations in the machinery for crushing canes, to extract 50 per cent. more sugar than is now done; or, in other words, every estate now making 100 tons of sugar loses 50 tons in the megass—one third of a crop which has been brought to maturity at a heavy expense, and the proceeds of

which, if brought into the market, instead of being wasted in the megass, would, even if manufactured in the usual faulty manner, in a short time be sufficient for the purchase of a steam engine and improved mill, and so save the necessity of embarking further capital. The average yearly loss of sugar in the West Indies, from this source alone, is supposed to amount to 70,000 tons.

Many planters are impressed with the idea, that wind is the most economical power which can be applied for driving cane mills, whereas the reverse is the case; for not only is it the most unmanageable force which could be used, but it is so uncertain, that great delay and loss are often experienced, either from a deficiency of wind, or from its being so boisterous and squally as to be dangerous; and, indeed, even when a fresh breeze does prevail, and the planter congratulates himself upon the rapidity with which his work progresses, he is actually, though unwittingly, the greater loser, because, as we have seen above, his loss of juice is greater in an exact ratio as the mill revolves more rapidly. Mr. Daubrée, in alluding to this circumstance, remarks,—“ Sometimes the breeze is so violent, that the mill is fed with difficulty, and liquor overflows on all sides. The unsuspecting planter congratulates himself on his good luck, forgetting that his canes are less pressed in proportion to the increased velocity, and that in fact he is then losing perhaps 10 per cent. more than usual.”

The irregular velocity of the windmill renders it much inferior to any other description of mill for crushing canes.

This fact has been repeatedly shown by comparative results, carefully noted by different persons. Amongst others, I will instance the returns obtained by M. Dupuis from 44 mills in Guadaloupe.

Water power averaged 61·8 per cent., animal power 58·5 per cent., steam power 60·9 per cent., wind power 56·4 per cent. These results were obtained from the best constructed mills of that island, and do not represent the inferior windmills, the return from which, M. Daubrée states, does not exceed 50 per cent.

Water power exists only in some few favoured localities, and is almost unknown in the smaller islands; and although it is at once economical, powerful, and easily regulated, the supply is often irregular, and, in seasons of drought, cut off either totally or partially, and for that reason is liable to one of the same objections as wind power, viz., that it cannot always be made available.

Of animal power I shall not speak, as no one is likely to defend such a rude and barbarous process, and which can never be rendered so economical as steam.

The steam engine is far superior to any other motive power in economy, force, regularity of action, independence of all local influences which affect other motions, the perfect control under which it can be maintained, the ease with which it can be directed, and its readiness of adaptation to any purpose for which it may be required, the waste steam also being useful for many purposes in the manufactory, where elevated temperatures are necessary.

The rollers should always be disposed horizontally, an arrangement which possesses great advantage over the vertical rollers in the ease and regularity of feeding, and in the equable wear of the surface; nevertheless objections have been raised to it, which have, however, been successfully combated. Dr. Evans says, "One evil attending the mill composed of three horizontal rollers is, the re-absorption of a part of the cane juice, by the squeezed but spongy megass. Another and much greater one is, the loss of power caused by the oblique direction of the crushing force, and the inordinate amount of friction."

These remarks Dr. Mitchell ably controverts as follows:—"Re-absorption certainly takes place, but to a most trifling degree, when the motion is slow, but is much more than counterbalanced by the increased facility of feeding. The second is a chimera, for the rollers, however placed, so they be parallel, must lay hold of the cane, and deliver it at a tangent, to the force developed at their periphery. Friction has equally little to do with the position of the rollers. The conclusions of Rennie and Morin are, First, Friction is simply *as the pressure* without regard to surface, time, or velocity. Second, Its amount is independent, for one and the same body of the extent of surface of contact; hence it is neither increased by turning vertical rollers into horizontal, nor by lengthening the latter, while the pressure remains equal," &c. &c.

In the construction of rollers for a horizontal mill, two things should be borne in mind. First, That the length

should be sufficient to allow a large number of canes to be passed through them at once, so as to ensure a rapid yield of juice, conjointly with slowness of motion. Second, That the diameter of the rollers should be sufficient to allow the canes to be taken hold of readily, without the necessity of grooving, and to ensure the more perfect pressure and lamination of the canes ; because, in rollers of large diameter, the points of pressure not being so acute as in smaller ones, the canes are more perfectly laminated, and the megass is delivered dry, without being reduced to fragments. The continuous sheet in which it is delivered, tends also to prevent re-absorption, as by a little mechanical arrangement, it can be made more immediately to leave its contact with the other roller, while the uninterrupted pressure prevents any of the juice passing over the upper surface of the roller along with it. In a powerful mill, with horizontal cylinders of large diameter, revolving slowly, the megass ought to be delivered like a sheet of thick pasteboard, and I have no doubt in that case, that 80 per cent. of juice would be readily obtained from canes of an average quality, leaving only 10 per cent. in the megass, a quantity so small as not to be sensibly appreciable, and from which a powerful hydraulic press would get very little more ; so that, assuming the cane to contain 18 per cent. of sugar, such a mill would extract 16 per cent. instead of the 10 per cent. usually obtained, leaving only 2 per cent. in the megass, a quantity so small as not to warrant the expense of machinery for its extraction. But

even this may be rendered profitable by the aid of a well contrived machine for affusion and repressure, for the purpose of fermentation and conversion into rum, along with the uncrystallizable melasses. Rollers such as described would vary from four feet in length for small mills, to six feet in powerful ones, and the diameter should never be under 25 inches, although 30 inches would be preferable, as such a mill would feed more easily and laminate more perfectly. In calculating the velocity with which a roller should revolve, its diameter must be considered, as the number of revolutions per minute becomes a most indefinite term when applied indiscriminately to rollers of different diameters. Thus if we suppose two rollers of 24 and 30 inches respective diameter, to be each making two revolutions per minute, the surface or periphery of the smaller would be travelling only 12 feet, while that of the larger would be going at the rate of 15 feet per minute. The speed should never exceed 15 feet per minute, or two revolutions of a cylinder of 30 inches diameter.

It is evident that when the size of the cylinders is increased, a greater force is required to set them in motion, and overcome the immensely increased resistance of the canes. This is accomplished by augmenting the size of the gearing wheels in proportion to the driving pinions, or by introducing another wheel and pinion, which has the double effect of increasing power and diminishing motion. Those which I have lately seen have had the gearing wheels increased in size to produce the required effect. It is

possible to alter the construction of the gearing wheels, &c., of the rollers of wind mills, (when the rollers are horizontal,) so as very much to increase the yielding of juice, by decreasing the velocity of the rollers; but the speed could not be regulated with exactness from the irregularity of the motive power. The frame-work, gudgeons, and wheels must also be made more massive than usual, to enable them to resist the additional force which would be developed. Every part of the mill with which the cane-juice comes in contact, and all spouts and strainers, should be formed of metal, as wood absorbs a portion of the liquid, which becomes acid, and communicates the taint to every succeeding portion with which it comes into contact.

CHAPTER III.

PROPER METHOD OF CUTTING CANES—IMPURITIES OF CANE-JUICE DESCRIBED—SOLUBLE SALTS—AZOTISED COMPOUNDS—NON-AZOTISED VEGETABLE PROXIMATE PRINCIPLES—MATIÈRE DELIQUESCENTE OF HERVEY—IMPURITIES WHICH CAN BE REMOVED MECHANICALLY.

CANES should always be cut as close to the earth as possible, both on account of the superiority of the shoots which will in that case spring for ratoons, and because the lower joints of the canes are the richest in saccharine matter. The upper joints should be unsparingly cut off with the top, as they not only contain little sugar, but their juice abounds more in soluble salts, than that of the more mature portion of the cane, and therefore is productive of mischief during the process of manufacture. For the latter reason all young shoots and leaves should be carefully removed from the canes before they are brought to the mill.

The impurities contained in cane-juice are the contents of the sap vessels which are ruptured by the pressure, and which become thus mingled with the cell-juice,

which, *per se*, is pure sugar and water, and fragments of the solid portion of the cane, separated by the same cause. They may be briefly classed as, First, Soluble salts, composed commonly of chlorides of sodium and potassium, sulphates of potash and lime, bisilicate of potash and alumina, &c. Second, Azotised compounds, concerning the exact varieties of which much difference of opinion exists among scientific persons. Third, Non-azotised vegetable proximate principles. Fourth, A highly deliquescent substance, observed and described by Hervey. Fifth, Particles of the solid structure of the cane, which have been separated by the force of the pressure employed in procuring the juice, and which consist of the ligneous matter composing the cellular and vascular tissues, and portions of the rind, particles of chlorophylle, (or the green colouring matter of the buds and leaves which is diffused through the structure of the cane near its rind or surface,) and of a kind of wax called by the French chemists, *cerosie* or *cerosine*.

The quantity of saline matter varies much in canes grown in different localities, and abounds most in those which are over-manured, or grown in soils containing much potash or soda, which substances, although they stimulate the rapid vegetation of the cane, exert an injurious influence on the conversion of its juice into sugar, from the excess in which they exist in it. Canes grown under such circumstances are always soft and watery, delicate in their structure, apt to lodge and rot

upon the ground, never ripen kindly, are sooner affected by changes of season, do not endure drought, but begin at the same time to wither at the top, and decay at the root, and their juices contain less saccharine matter than those of canes which are less forced in their growth, and whose structure is more fully and firmly developed; these rank, watery canes, always make bad sugar, and are familiarly termed by the negroes in some of the islands, "washy canes." This may account for the prejudice which has arisen against the use of guano as a manure, in consequence of the inferior quality of the sugar produced from canes which have been manured with it, and the rapidity with which the tops wither when the weather becomes dry.

We may also notice, that in canes which are grown in situations where they are exposed to the influence of the sea spray, very rapid changes occur on every alteration of weather. Canes so circumstanced are always the first to suffer from drought, and revive the most rapidly after a shower. I have been led to suppose that this does not altogether arise from the excess of saline matter in the soil, but from an incrustation of salt which, during dry weather, is deposited on the leaves, and by obstructing their pores, produces an unhealthy action in the plant; and that every shower which falls, not only frees it from this obstruction, but washes down a fertilizing substance to the roots, and stimulates the cane to more rapid growth. Canes produced in such localities always contain an excess of chloride of sodium, and their juices make a sugar inferior

to that procured from canes grown more inland. The quantity of melasses is always greater, and the sugar more deliquescent than usual; the greater part of the salts drain off with the melasses, but there is always a portion adhering with the colouring matter to the crystals, and this causes deliquescence. I have seen sugar, on the windward coast of Barbadoes, manufactured from such canes, the melasses from which was as salt as if it had been mixed with strong brine.

These saline constituents being soluble, and forming highly deliquescent compounds, cannot be extracted from the cane-juice, but pass off in the melasses, they exert an injurious influence upon the sugar, and the process of manufacture should therefore be as rapid as possible, to prevent the ill effects of prolonged contact with them. In the juices of good canes they exist in very minute quantities, averaging from 2 to 4 parts in 1000. Hervey thus describes their action:—"Saccharine juices always contain a greater or less quantity of salts, and it is well known that sea salt combines with cane sugar, giving rise to a deliquescent compound, containing 6 parts of sugar for 1 part of salts, and this remains in the melasses in the state of uncrystallized syrup. But the chloride of sodium is not the only salt which can combine with sugar, and exercise an injurious action on crystallization. This process is impeded by various salts. Of these the halogenous occupy the first rank. Even at the temperature of striking, the carbonates of potash and soda react on sugar, rendering

the syrup high coloured and almost uncrystallizable." Dr. Evans, in describing the saline constituents of cane-juice, remarks:—"I have already stated, on the authority of Peligot, who has given much attention to this subject, that one part of chloride of sodium will combine with nearly six times its bulk of sugar, and form a deliquescent compound which is capable of liquifying another portion of sugar equal to itself in bulk. It is also very probable that the other saline constituents may likewise form similar combinations. Their presence therefore must always be considered injurious." There is no means of removing these saline substances from cane-juice when once infused in it; therefore, as I have before observed, the utmost rapidity of manufacture is necessary to limit their deleterious action as much as possible, particularly when they exist in excess.

The azotised substances contained in cane-juice consist of some compounds of proteine, which, although they approach nearly to the appearance and properties of the recognised varieties which exist in other vegetables, are not all similarly acted on by the usual re-agents, and from this circumstance, much difference of opinion has existed among the various persons who have examined them. One of the most important, or, at least, the most prominent of these compounds, is a substance resembling vegetable albumen, and, like it, readily coagulated by heat or infusion of tannin, but which does not undergo any change, or, at least, any instantaneous change, when exposed to the

action of the usual tests, nitric acid, bi-chloride of mercury, and creosote. It is, however, sufficient for the sugar manufacturer to know, that it can be coagulated by the agency of heat, and removed by filtration, and it will probably be designated albumen, till some more definite appellation is bestowed upon it. I should, with all diffidence, however, distinguish it as "cane albumen," as it appears to be peculiar to that particular plant. Particles of fibrine and gluten are also detected in fresh cane-juice. The latter, no doubt, forms the "*matère globulaire*" of Peligot, who says that it does not exist in the fresh cut cane, but is rapidly developed in the newly expressed juice. It possesses the power of immediately generating viscous fermentation, but such power is destroyed by raising the temperature of the juice to 160° F. Dr. Davy, in describing the appearance of fresh juice, says,—“However carefully expressed, it is never transparent, it is turbid in a slight degree, and coloured. If viewed under the microscope with a high power, innumerable granules will be seen floating in the fluid, in diameter varying from the ten thousandth to the fifteen thousandth parts of an inch. By filtration through bibulous paper, it may be made transparent, or nearly so, and most of these granules separated. The matter of these particles consists, I believe, chiefly of the nature of gluten, and, like gluten, has the power of exciting fermentation, as I have ascertained by various experiments made both on the substance procured by the filtration of the freshly expressed juice, and

on some sent me by my friend Mr. Best, from "Blackmans," found adhering to the gutter by which the juice was conveyed from the mill, and which, after having been kept nearly twelve months, still retained the qualities of a ferment." This substance is observed by every one employed in sugar manufacture. It adheres to the sieves, pipes, and gutters through which the cold juice passes, is slimy to the touch, and, when examined closely, appears in globular particles, which are, no doubt, aggregates of smaller ones, like the roe of a fish. These particles can be removed by filtration, as they are insoluble, or nearly so, in water; but as gluten is dissolved by alkaline lyes, it should be removed before the addition of lime.

Caseine exists in cane-juice in a soluble form, and is not like albumen coagulable by heat. In order to effect its coagulation, a little lime must be used, care being taken not to use it in excess. In treating of this substance, Dr. Evans remarks,—“When cane-juice, which has been already boiled and filtered, is submitted to the action of heat a second time, the flocculent particles which separated from the liquid during the first ebullition, are not now observed, but in place of them a thin film is seen to form on the surface. A similar effect is produced on all liquids which contain caseine in solution. We have a familiar instance of this in boiling milk. It has been already stated, that caseine is one of the proteine compounds found in cane-juice, in which it is held in solution by the presence of a vegetable acid, or acid salt, in the same way

as it is found combined in the juice of the grape. As caseine cannot be separated from its solutions by heat alone, it is evident that when this agent is the only one to the action of which cane-juice has been submitted, the caseine must still remain dissolved in its original quantity. Syrups prepared from cane-juice thus treated, undergo a partial crystallization only, and are very much disposed to run into one or more of the varieties of fermentation just alluded to. Boiled cane-juice likewise changes its chemical character with great rapidity, the three varieties of fermentation taking place in it simultaneously. But while the viscous and lactic acid fermentations predominated, as we have seen, in the juice which has not been exposed to heat, this viscous fermentation is the one which is the most active. Caseine is, as has been already stated, insoluble in pure water, but when the water has been acidulated by the addition of any of the vegetable acids or acid salts, or when it is rendered alkaline by a small quantity of potash, soda, or lime, it becomes, in both cases, a solvent of this principle. In the one it is separated from its solution by the addition of an acid; in the other by that of an alkali, *provided neither be in excess, otherwise it is first precipitated, and afterwards re-dissolved.* We can thus explain the necessity for the employment of lime in the defecation or clarification of cane-juice."

The non-azotised vegetable proximate principles, except cane-sugar, exist in a very small quantity in the fresh juice, but rapidly increase at the expense of the sugar

in solution, which, by fermentation, is quickly converted into various other substances, as glucose, gum, vinegar, alcohol, &c. &c. This also shows the necessity of *immediate* defecation. Dr. Evans says, that ripe healthy canes contain from one to four parts in a thousand of dextrine; and Dr. Davy says, he invariably detected starch in the matter separated from the fresh juice by filtration, using iodine as a test, and aided by the microscope.

Of the substance designated by Hervey, "*matière deliquescente*," I shall give his own description. He says,— "It is soluble in water, neither sweet nor salt, leaving no ashes on incineration. We are inclined to think that in manufacturing on a large scale, it may play an important part in the production of melasses, that is, if it does not combine with the sugar, it tends naturally to augment the viscosity of the crystallizations from the melasses. The substance is colourless when obtained by evaporation in vacuo, or at a low temperature, but becomes coloured by the action of heat. Its aqueous solution offers two distinguishing characteristics: it is precipitated by tannin, and absorbed by pure animal charcoal, in such a manner that cold water no longer removes." Dr. Evans says of it,— "When a portion of sugar cane, cut into thin slices and dried, is infused in cold alcohol, a peculiar substance remains in solution, which is obtained on evaporation. It is neither sweet nor salt to the taste, is uncrystallizable, and highly deliquescent. It is the '*matière deliquescente*' of Hervey. Its composition is unknown."

The grosser particles of ligneous matter, wax, &c., ought, if possible, to be removed by metallic strainers of various degrees of fineness, which should be continually shifted and purified, to prevent any formation of acidity, or accumulation of a glutinous ferment.

CHAPTER IV.

IMPROVEMENTS ARISING FROM THE EFFORTS TO RENDER THE PRODUCTION OF SUGAR FROM BEET-ROOT PROFITABLE—DR. MITCHELL'S EXPERIMENTS ON HEATING CANES TO PREVENT THE DEVELOPMENT OF THE FERMENTATIVE ACTION IN THE JUICE AFTER EXPRESSION.

THE efforts made by the French to render the production of sugar from beet-root profitable, called forth a vast amount of scientific research, and adaptative ingenuity. Among other successful experimenters, M. de Dombasle, who, acting on the principle laid down by Liebig, of the property of organic substances to pass into a state of fermentation and decay, in contact with atmospheric air, being annihilated in all cases, by heating to the boiling point, has succeeded in obtaining the sugar by the process of cold maceration, after first destroying the vitality of the beet by ebullition.

Dr. Mitchell, carrying out this suggestion further, has lately made some experiments with canes, by plunging them into boiling liquids, previous to the extraction of the juice, and thus destroying the vitality of the incipient "*matière*

globulaire," and coagulating the albuminous substance in the tissue of the cane, so as to prevent its expression along with the juice. The results of these experiments I shall give in his own words. He premises, by saying, that the experiments were made at Woodbrook mill in Trinidad; and, previous to these experiments, the mill was washed and sprinkled with lime water, and some of the canes which had been heated were passed through it. "The liquor obtained was colourless, full of floating feculæ. These immediately subsided, and the residue, boiled down without skimming, furnished a white sugar, without being submitted to any ulterior operation. Some of the liquor kept till next morning (18 hours) perfectly neutral, but towards noon became acid and ropy. The proportions of liquor and megass were changed. The former diminished in quantity, but notably increased in density; the latter gained in weight and tenacity to an unexpected degree. *

* * On a second trial, a quantity of canes were heated, by being dipped in the grand copper for $2\frac{1}{2}$ minutes. They were ground off 15 hours afterwards, being at that time 6 days cut. The liquor was received in mill tubs, one of which was particularly foul, having served as a receptacle for trash from the mill bed. This communicated a certain degree of acidity to the whole. Five wine gallons of this liquor, weighing 45 lbs., were taken and boiled down. When the first scum was removed, the remainder appeared like clarified syrup. No lime or other temper was used, and the return was 9 lbs. 8 oz., or more than 21 per cent.

The quality of the sugar, now that it has drained, appears equal to that produced in Guadaloupe, by twice passing through animal charcoal, and boiling in vacuo. The melasses, or rather syrup of drainage, appeared nearly equal to that from which the sugar crystallized. Under the microscope, the crystals were not rhomboidal as usual, but cubes, having their edges replaced by planes, crystals, pure, with sharp, well-defined edges, showing that a perfect sugar may be obtained, without having recourse to lime. This point also furnishes matter for grave consideration, for every pound of lime, used in defecation, immediately unites with six pounds of sugar, forming saccharate of lime, coagulating by heat, and rejected as skimmings, but not till its influence has destroyed the crystallizing power of an equal quantity of sugar, effecting a total loss of fourteen pounds. On comparing the liquor from heated canes, with that in its ordinary state, the result was as follows:—Twelve lbs. of the former, presenting the usual white appearance, without the same tendency to subside immediately, were tempered with three tea-spoonsful of milk of lime. Ten minutes were allowed for subsidence. On applying heat, the liquor threw up a scum, and then boiled down with rapidity, not, however, without the occasional appearance of impurities on the surface, probably saccharate of lime. The return was 36·8 oz., or 19·15 per cent. Twelve lbs. of ordinary liquor, from similar canes, exposed immediately afterwards, were tempered hot, required nine tea-spoonsful of milk of lime, were troublesome to skim, and

returned 25·7 oz., or 13·9 per cent. Of these two, the heavier sugar was much the finer, and cured with more facility. The drainage, in taste and smell, resembled syrup more than melasses, and is now depositing crystals equal in quality to the original sugar. During this trial it was remarked, that while ordinary liquor was brightened by a due addition of lime, that from the heated cane became tinged with green, and this shade extended to the sugar; the alkali had no doubt dissolved and liberated chlorophylle, previously fixed by heat, among the coagulable constituents. Two thousand lbs. of cane were next taken, and equally divided. One half was heated, and on being passed through the mill, yielded 63 lbs. of liquor, and 37 lbs. megass. Thirty-two lbs. of this juice gave 93 oz. saccharine matter, or rather more than 18 per cent. It is to be here observed that the original weight, 32 lbs., includes that of all the ferculæ, separated by lime. Had the per centage been taken on clarified liquor, it would have been much higher. On adding the lime, the green tinge was more strongly marked than in the preceding case, but it greatly diminished with the drainage. The unheated portion of the canes gave 68 lbs. liquor, and 32 lbs. megass, being a difference in fuel of 16 per cent. in favour of the heated cane. The fibre of the latter becomes tenacious, tears with difficulty, and when the cane was sound, fell from the mill in one uninterrupted ribband, being fit for fuel in a few hours; while the ordinary megass, from which 68 per cent. liquor had been extracted, was much more torn, and only fit

for burning in three or four days. There is no increased expenditure of fuel in thus heating the cane. It forms the first step in evaporation, and clarifies the liquor before it is exposed to atmospheric action, and the irruption of the azotised elements into the cells. The excess of heat escaping from the crushing cane, carries with it the surrounding moisture, and the fibre is immediately dried. * * *

In testing the density of the respective liquors, it was found, that while the ordinary mill liquor marked 10°, the other marked 11° Beaumé. * * * The microscope shows no alteration in the appearance of the cells, after exposure to elevated temperature, and indicates the probability, that while, by the action of heat, many of the unelaborated constituents of the sap are fixed in the fibrous tissue, the cells themselves are ruptured, and pour forth, under the action of the mill, a nearly pure secretion, dense in proportion to the maturity of the plant. The purity of the liquor will simplify the boiling-house arrangements, and the present regiment of clarifiers and coppers be replaced by flat pans commensurate to the work required."

It is evident from the result of these experiments, that by exposing the cane to a temperature equal to that of boiling water, the albumen and chlorophylle become coagulated, and the vitality of the other proteine compounds is destroyed or arrested while yet in the cane. The megass becomes sensibly increased in weight and tenacity, by the fixing of these substances in the fibrous tissue; and the evaporation of moisture, by the escape of heat during

the act of crushing, renders the juice more dense, and reduces the amount of subsequent evaporation. It is therefore a question, whether the mechanical arrangement for heating the canes can be sufficiently simplified so as to present no inconvenience more formidable than the arrangement of the clarifying vessels, and complex method necessary for separating the impurities, after expressing the juice in the ordinary way. I am of opinion, that the heating of the canes before grinding would not prove an insuperable difficulty, particularly if the agency of steam could be employed. Exposing the canes for a few minutes to a high degree of heat in a steam chest or tube, would probably be attended with more decided advantage, and could be more rapidly and economically effected, than by immersion in a boiling liquid. From some conversation I have had with an experienced engineer in this country, I am inclined to think this could be done without difficulty; and in Demerara, where the canes are conveyed to the mill in iron punts, which could be fitted with covers sufficiently steam-tight, it would be easy to effect this object, by a steam pipe from the boiler, which could be affixed to the punt, and disconnected at pleasure.

The subject presents matter for serious consideration to those who are interested in it, and I have no doubt, if the system were carried into effect, it would realize all the advantages proposed by its adoption, being based on sound reasoning, and the results of the experiments already made, having proved successful, even under unfavourable circumstances.

CHAPTER V.

SIMPLE METHODS OF DEFECATING CANE-JUICE—METHOD OF DEFECATION WITHOUT ANIMAL CHARCOAL—METHOD OF USING ANIMAL CHARCOAL—VARIETIES OF CHARCOAL FILTERS.

I SHALL now proceed to describe the most simple and perfect methods of defecation, and the apparatus necessary for performing the operation, premising, that the success of any plan for defecating cane-juice, depends upon the rapidity of its action.

Two methods present themselves as the most simple and certain, the first being accomplished by the defecating agency of "Tannate of lime," and double filtration through calico filters; and the second, by filtration through animal charcoal after defecating with lime alone. To perform the first process effectually, double receivers or clarifiers are required, the juice being filtered from the first into the second, and again filtered before passing into the evaporating vessels. As it would be most convenient to apply heat to these vessels by steam coils or worms, I shall consider, in the process to be described, that the canes have been ground in a mill with horizontal rollers, driven by steam power, with a boiler

of sufficient size to supply the requisite steam for heating the defecating vessels. The arrangement could, under other circumstances, be modified according to convenience or necessity.

The first and most important object, is to raise the temperature of the juice, after its expression, to the boiling point as rapidly as possible, and so prevent the tendency to injury from atmospheric influence, and destroy or arrest the action of the glutinous ferment, or "*matière globulaire*," which becomes developed *immediately* after expression, and is only destroyed by exposure to an elevated temperature. It would be well, if it could be done conveniently, to have the mill bed, upon which the juice first falls, constructed with a double bottom of strong boiler plates, within which high pressure steam could be admitted at pleasure, by a cock from the boiler; this would not only assist in heating the juice at once, but would prevent the accumulation of any acid or ferment in the mill itself, a circumstance which occurs to a certain degree even in those mills which are most carefully cleansed, and to a most injurious extent in others which are not. I believe that this plan has been tried in one of the French colonies. It is open to the objection, that the framework of the mill might be distorted, by the expansion of the lower portion, from exposure to a high temperature; but this might be remedied by having a *false* double bottom unconnected with the frame of the mill; and perhaps it would be advantageous if this was made of copper. Double metallic

strainers, with meshes of different degrees of fineness, should be placed in such a position, that the liquor would pass through them immediately after leaving the rollers, and so constructed that they could be readily and speedily removed for the purpose of cleansing. They should also be so arranged, that a clean set could be inserted above or below those which were becoming choked, before their removal. These strainers ought to be made entirely of metal, and no wood used in the frames, as it absorbs a portion of the juice, and cannot be kept free from acidity. By this means all the coarser impurities from the juice will be removed before it passes into the clarifiers. The number of clarifiers should be regulated by the power of the mill, or the amount of work required from it, and they should be placed as close to it as possible, to prevent the injury which results from the passage of the juice through long pipes or gutters, often coated with glutinous ferment. Each clarifier or defecator should be capable of containing from 300 to 600 gallons, according to the scale of the works, and should have a second vessel of similar capacity, and with the same appliances for heating the juice, placed upon such a level, that the liquor can be filtered from the first into it. On the liquor flowing from the mill into the first clarifier, it should, as quickly as possible, be heated to ebullition, which will cause the coagulation of the albumen in the meshes of which, the particles of chlorophylle, and the smaller insoluble impurities which have escaped the strainers, will be entangled and enveloped. After being

made to boil smartly for a few minutes, and any scum which may appear removed, the heat should be withdrawn, and the liquid passed through calico filters into the next vessel. No lime or other temper should be used during the first operation, as lime has the effect of redissolving a portion of the albumen, which does not reappear till the liquor becomes more concentrated by the increased heat, and the lime would also liberate a portion of the chlorophylle, and communicate a green tinge to the liquor.

By the process just described, the liquor will have been freed from its insoluble and albuminous impurities, and will then contain "caseine," the "*matière deliquescente*," and the soluble salts. In order to separate the "*matière deliquescente*," an infusion of tannin must be used, which can easily be prepared from nutgalls. Dr. Evans gives the following simple directions for preparing it:—"To two ounces of nutgalls, finely bruised, add half a-gallon of boiling water: infuse for 12 hours, and strain." The above quantity the Doctor describes as sufficient for 400 gallons of juice, but the exact amount can be best determined by practice. I have found a less quantity enough for producing a sufficient coagulation in 500 gallons. Before adding the infusion of tannin to the liquor, the latter should be accurately neutralized by milk of lime, using litmus paper as the test. By this means the coagulation of the caseine will be effected, after which, the infusion of galls must be added, which will cause the coagulation of the "*matière deliquescente*," leaving in a state of solution, in the liquor,

only the sugar, and soluble salts of potash and soda. If any excess of acid appear after the addition of tannin, it must again be accurately neutralized by lime, and the liquid brought to ebullition. It must then be immediately passed through calico filters, and conveyed to the evaporators as rapidly as possible, when the more quickly it is converted into sugar, the less will be the loss sustained by contact with the soluble salts, for the removal of which there is no convenient process.

The second method of defecation is exceedingly simple, and requires only a single set of clarifiers; but the liquor must be afterwards filtered through animal charcoal. The cane-juice, after flowing from the mill through strainers, as in the former method, should be *immediately* brought to ebullition, and after smartly boiling for a couple of minutes, and removing all the scum which rises, the liquor should be accurately neutralized with milk of lime, which has the effect of coagulating the caseine, but at the same time redissolves a portion of the albumen and chlorophylle, and if at all in excess, forms a saccharate of lime, with a portion of the sugar. These injurious consequences, however, are all obviated by filtration through animal charcoal, which retains the organic impurities, and decomposing the saccharate of lime, sets free the sugar, which passes through nearly in a state of purity, while the lime is retained in the filters. After this process, the liquor, as before, contains only the sugar and the soluble salts of soda and potash, and should at once be conveyed to the evaporating vessels.

Some persons think it unnecessary to pass the liquor through the charcoal filters, until it has been submitted to the process of evaporation, and has acquired the density at which it is proper to transfer it to the vacuum pan, or otherwise finish the concentration at a low temperature; but there can be no doubt it ought to be passed through the charcoal on leaving the clarifier, after being first freed from its insoluble impurities by calico filters, as otherwise a loss is sustained during the process of evaporation, from the scum thrown up, a portion of which consists of sugar, combined with lime, which becomes gradually insoluble from the increased heat to which it is exposed in the evaporators, and is rejected as skimmings.

By either of the plans proposed, the labour of skimming during the process of evaporation is rendered unnecessary, as the solution of sugar and water is nearly pure, and will throw up no scum. It may be objected to the success of the first process of defecation, without the use of animal charcoal, that the separation of the albumen will not be complete, as the very dilute state in which it exists in cane-juice requires a greater degree of heat than 212° F. for its perfect coagulation. This supposition is very doubtful, but even if there should be any left in solution, after being exposed to that temperature and to contact with infusion of tannin, the quantity must be very small, and not likely to be productive of injury. Many other methods of defecation have been proposed as substitutes for the usual imperfect one. Dr. Evans describes nine different modes,

but of these, the two most efficacious are dangerous from poisonous ingredients being used, and would therefore be improper to be intrusted to careless persons. There are also several patented processes, but their success is as yet undetermined, and they are open to similar objections. The filters generally employed and recommended are Taylor's bag filters, which have long been used in the refineries in this country; but a much more simple and equally effective method is used by the French, both in the beet-root sugar factories, and also in the sugar colonies. It is thus described by Dumas:—"In a large box are placed vertically a score of flat cotton sacks, kept distended by a slight wicker frame," (a spiral copper wire would answer this purpose and be more easily kept clean,) "the liquor to be filtered is poured at once into the open space between and around the sacks, so that filtration, contrary to what happens in Taylor's system, takes place from without. The filtered liquor flows into the double bottom of the box, through a hole in the bottom of each sack. The advantages of this plan are apparent, for as no deposit can be made on the inside of the sacks, they will not require such frequent cleansing; and for the same reason the filtration is more rapid, and the washing of the sacks accelerated." Of the apparatus for filtration through animal charcoal, Dumont's and Peyron's are most commonly used. The first is well described by Dr. Mitchell:—"They consist of a range of boxes, varying in size and number with the daily quantity of sugar required. They

should contain an aggregate of charcoal at least one half the weight of the sugar they are intended to purify. Each filter consists of a box, whose cubic contents may vary from 300 to 600 lbs. weight. Three inches from the base is a false bottom, consisting of a metallic sheet, perforated like a sieve. Between it and the bottom are two orifices, one opening externally, the exit pipe for the filtered liquor; and the other internally, being the end of a tube passing up through the box; for the air, which is contained in the interstices of the charcoal, is pressed down by the descending syrup, till it finds its way out by the tube: this latter terminates within the box, so that in case of puking, which sometimes happens through carelessness, the syrup is returned into the upper strainers. The air tube is sometimes on the outside of the vessel, in which case its end is carried inwards so as to hang over the syrup. Although the manipulation is easy, it may be as well to revert to a few points which unaccustomed boilermen might overlook. The false metallic bottom, pierced with holes, is covered with a fold of blanket, first wetted and slightly wrung out. It is so placed as to touch the sides of the filter all round. Upon this cloth is spread a layer of charcoal three inches deep. This is levelled with some degree of pressure, and successive layers are added till the whole attain a depth of from fifteen to eighteen inches, when it is covered with a cloth and metallic plate similar to the first. Instead of the metallic plate covering the whole surface, many planters use merely a piece of thin copper about five

inches square, which is placed beneath the delivering cock, to prevent the washing away of the charcoal. In filters of the size described, the depth of syrup above the superior metallic plate, should be regulated at four inches. This has been decided by practice, as the most suitable depth, and can easily be regulated by a float-cock. A greater depth in these small vessels is found to create what are called false-channels, through which the syrup runs without filtration. On leaving the filters the syrup is colourless. Whenever it retains a portion of colour, the charcoal is then considered as exhausted for the time, and must be renewed. The process of revivifying charcoal, by which its decolourating power is restored, consists simply in washing and burning in suitable vessels. * * * Eight filters such as have been described, and lined with zinc, may be purchased in Havre for £16 sterling. They are sufficient for a boiling house making from 3 to 4 tons per day. Two are recharged daily." Peyron's filters are thus described by Dr. Evans:—"These filters are composed of a series of cylindrical copper vessels, each having a double bottom as those of Dumont, and being hermetically closed at the top. They are closely packed with animal charcoal; and into the upper part of the first vessel is introduced a pipe for the admission of the syrup, which is made to descend from a sufficient height, or which is forced in by means of a pump, in such a manner, that from the pressure employed, it passes rapidly through the charcoal, and is received by the space between the two bottoms. Here it enters another

pipe which conveys it to the upper part of the second filter, placed close by. Thus it continues through the whole series, until it is at last drawn off by a cock placed for the purpose in the last vessel. Each of the cylinders is 6 feet high, and three feet in diameter. Three of them would be required in a boiling-house making 3 hhds. a day. They act well for about five or six days. The charcoal is never removed from them, but when its powers require to be restored, boiling water is introduced for the purpose of washing away as much as possible the syrup remaining in the interstices. The sweet liquid which comes away is thrown into the evaporating vessels, while the filters are put into some warm place, that fermentation may ensue. It is stated that this fermentation is completely terminated after 24 or 36 hours. In this way the organic matters which had neutralized the decolourating powers of the charcoal are destroyed, and to restore its properties, nothing more is required but an effective washing. This is best performed by the injection of high pressure steam for half-an-hour. When steam is not used in the boiling-house, hot water must be passed through in a continued stream until it comes away clear and limpid." Dr. Evans also describes the following simple method of making a filter, which can be easily constructed in any boiling-house:—"Take a clean rum puncheon, and at the distance of two or three inches from the bottom, make a support sufficient to retain a piece of basket-work, corresponding in size to that part of the cask. Into the space between this and the bottom,

affix a cock. Carefully fill the cask with charcoal, up to about two-thirds of its height, avoiding all inequalities of surface; and cover it with another and similar piece of basket-work. The filter is now prepared. Introduce the hot syrup gradually and cautiously, until the puncheon is entirely full. Let it remain in contact for two hours, and then turn the cock. The first portion of syrup that comes away will contain minute particles of charcoal. It should therefore be returned to the evaporating vessels. Four puncheons so arranged will be required for an ordinary boiling-house."

CHAPTER VI.

EVAPORATION OF THE DEFECATED JUICE—NECESSITY OF RAPID EVAPORATION, AND DESCRIPTION OF APPROPRIATE EVAPORATING VESSELS—CONCENTRATION OF SYRUP AT A LOW TEMPERATURE—VACUUM PAN—GADDESSEN'S PAN.

HAVING in last chapter described the most effectual methods of defecation, the next part of the process is the conversion of the defecated juice into a syrup of the density of 27° or 30° Beaumé, to which point the evaporation may be carried on under the usual atmospheric pressure, without injury to the sugar, provided that the operation be performed rapidly. The vessels usually employed for this purpose are not adapted for the successful accomplishment of the end in view, not being of a proper shape to ensure rapid evaporation of the water, and, moreover, causing a great waste of fuel, by the heat being to a considerable extent absorbed by the brickwork in which the coppers are built. The form of the vessels should be such, that a large surface can be exposed to the *direct* action of the fire, and, at the same time, to have the portion so exposed constantly covered with liquor. For

this purpose, the oblong flat-bottomed pans proposed by Dr. Evans, are best adapted, as they answer every purpose for which they are intended, and have been used with complete success in Guadaloupe. For a boiling-house, making 3 hhds. per day, two evaporating vessels, each about 14 feet in length, 7 feet in width, and 18 inches deep, would be required, both fixed over the same furnace, and furnished with discharge-cocks, one of the pans being sufficiently above the level of the other, to allow its contents to be drawn off into it by a cock, and thus obviate the necessity for baling. The upper edges should be leaded, and the masonry sloped backward, as in the case of the ordinary coppers, to prevent the liquor from boiling over. If the liquor has been perfectly defecated and filtered, no skimming will be necessary, and only one man is required to superintend the operation. In drawing off the syrup, when it has acquired the necessary density, care should be taken never to uncover the bottom of the pan, as some of the sugar in that case would be caramelised and discoloured. The pan should therefore never be wholly emptied, until the fire is withdrawn at the close of the day's work. A strong fire should be maintained during the process, and a current of air be made to pass over the liquid, to hasten the evaporation. This can in most instances be readily effected by a partition of boards being placed at a convenient height above the inner part of the wall which supports the pans, and extending upwards and backwards to the upper part of the opening

left in the back of the boiling-house for the escape of the steam. This is called a chimney of aspiration, and is an effective method of sending a current of air across the surface of the boiling liquid, sufficient to carry off the steam as fast as it appears, when, as is usual in the lesser Antilles, the evaporating vessels are erected on the lee-side of the building, through which a current of air generally passes. Whenever this method cannot be rendered effectual, it would be advantageous to produce an artificial current of air, by means of an insufflator, or any other available method, as this would hasten evaporation, and economize fuel to a great extent. For the process of evaporation, if the vessels are of the proper form, the direct heat of the furnace is as effective as that of steam, the only advantage which the latter possesses in any part of the operation, being the ease with which the degree of heat can be regulated. Many planters imagine, that syrup does not become caramelised if concentrated in a steam tayche; but this is quite a chimera, the degree of heat and susceptibility of injury therefrom being in both cases alike.

The advantage which steam possesses in this, as in every other part of the process, consists in the ease and readiness with which it can be managed, any degree of heat as may be found requisite being easily applied, and the instant cessation of its action at command, when no longer required. The most important object to be attained in the process of evaporation is rapidity; and the vessels best adapted to accomplish this end are to be judiciously

selected, whether the heat be applied to them by the furnace, or by high pressure steam. As soon as the syrup has attained a density ranging from 27° to 32° Beaumé, according as it is to be again filtered or not, at which latter density it will have reached a temperature of about 220° F., it must be drawn off into a cistern or other convenient receiver, that the concentration may be finished at a lower temperature. A variety of plans have been tried to effect the rapid concentration of syrups at a low temperature, but the most perfect is by the vacuum pan, in which the concentration is finished, without injury, at a temperature of 160° to 180° F., and sometimes much lower. The high price of this apparatus has caused many contrivances to be made for effecting the object in a less costly manner. Some of these require a steam engine to work them, but in these the difference in cost not being very great, it would be far preferable to have the vacuum pan at once. Others are of a very simple and economical description; and of these the most useful is the vessel known latterly as Gaddesden's pan, although I believe it had been used in the French Colonies both in the East and West Indies, for many years before Mr. Gaddesden brought it to the notice of the public. Dr. Evans describes it as follows:—"This gentleman's apparatus consists of an iron or copper pan, having nearly the form of the half of a hollow cylinder, in which is placed a drum or wheel, adapted to the shape of the vessel, and formed of a number of metal rods so arranged that the

evaporating surface given to the syrup is increased as much as possible. The wheel, half its circumference being immersed in the liquid, is kept constantly revolving, so that by exposing fresh portions of the heated syrup to the action of the atmosphere, at each succeeding revolution, the evaporation of the aqueous particles is rendered more rapid than it otherwise would be, while the temperature is at the same time in a corresponding degree reduced. The time required to take off a skip in a pan containing one ton of sugar, varies from two and a-half to four hours, and the temperature of the syrup varies from 150° to 180° F. From the principles upon which this method of concentration are based, it is evident that its successful working will depend on the degree of dryness of the atmosphere, and on the rapidity with which the air passes over the surface of the syrup. The apparatus should therefore always, when it is practicable, be placed at the windward side of the boiling-house; at all events, it should be beyond the influence of the vapours which arise from the evaporating vessels." I have seen one of these pans tried in Antigua, but it was merely an experiment, and the pan was not in a convenient position. The temperature was easily kept down to 170° F. The bars of the drum wheel were made of wood instead of metal. Its uses have been successfully applied by a gentleman in Berbice. I have a description of its operation by the manager of the estate, which is particularly interesting, from the fact, that some trials of it in other places have failed, doubtless from want of atten-

tion, or imperfect defecation of the liquor. The following is the description of the process on the estate alluded to in Berbice:—"The sugar is granulated at a temperature of 175° F. The revolutions of the wheel do not exceed 2·5 per minute at any time. Rapid revolutions produce froth, even in well cleared liquor, and it is very difficult and often impossible for even experienced sugar boilers to get rid of it; it is therefore to be guarded against as much as possible. Having experienced sugar boilers, we do not strike with the saccharometer, but in several trials that I have made, I have found it to be from 43° to 45° Beaumé. A degree or two less is of no consequence, but a degree or two more would give too much heat to the syrup, and injure it. The old range of coppers evaporate in the first instance, and the liquor reaches a heat of about 224° F., which will give a density of about 32° Beaumé. We have a cistern which contains about 600 gallons, as receiver for the syrup, from the coppers, from which it is let into another cistern below, containing from 60 to 100 gallons. From this it is let into the pan at charges of about 8 to 10 gallons each time. We use no charcoal. We get as large a crystal as the vacuum pan, and we attribute it to the low temperature at which it is concentrated. It is, I believe, generally admitted, that too much caloric is detrimental to the aggregation of crystals. When the syrup (sugar) comes from the pan, it is run into a heater, heated by steam, where it is allowed to remain about 20 minutes; and when it is heated to 180° F., it is filled into cones

which are set up in any convenient place of common temperature, where it remains 18 to 24 hours. It is then received into a room heated by steam to 100° F.; the plugs are taken out of the bottom, and the melasses allowed to run off. In about twelve hours from this, a paste is made of clear water and sugar, which is put on the top of the cone, and then about a gallon of clear syrup is put through it, which carries down the impurities and melasses that are hanging about the crystals. Twelve hours after this, another gallon of syrup is run through; it then remains for four or five days to drain, when it is fit for shipping. In reboiling melasses (if pure melasses) there is some difficulty experienced in getting a grain at the first starting. We therefore generally leave about one third of syrup with the melasses. If there be no syrup at hand, then two or three gallons of dry sugar are put into the pan, while it is first working, which assists it very much. In all cases the melasses must be fresh, not more than three or four, or, at most, six days old. The syrup which is run through the cones to clear the sugar, mixing with the melasses in the same cistern, forms a very good article from which we generally get five lbs. of sugar per gallon." The proprietor of the estate on which the pan was used, said, that sugar manufactured in the manner described sold for £25, when common sugar was selling at £14 per hhd. The only objection to this pan is, that it is apt to burn at the edge of the syrup, when the couch of the latter is shallow, but this has been successfully remedied by applying the

same principle to a rectangular flat bottomed pan, the fire being allowed only to come in contact with the bottom. Dr. Mitchell describes one of this sort as follows:—"One of the most efficient articles of this kind I saw, was a large iron rectangular pan, made by Crossley. It cost £25 sterling, including furnace mouth and bars. Its dimensions were $6\frac{1}{2}$ by 6 feet, 18 inches deep at the sides, by 22 in the centre, the bottom being slightly concave, to facilitate the exit of the contents through a large cock. The drum, made of white pine for the sake of lightness, had every second bar bucket shaped, to take up a greater volume of syrup. Its dimensions were such, that the lower portion of the circumference, suspended in the syrup, dipped down to within two inches of the bottom of the pan. The wheel on the axletree had eighty teeth, and the driving pinion seven teeth; made two turns in fifty seconds, and receiving the syrup (marking 220° F.) when hot, turned out 180 gallons liquid sugar in seventy-five minutes, at a temperature of from 164° to 170° F. The coal used was 175 lbs. Time and fuel would be saved by using Hague's, or any other insufflator, for driving across the pan, while in action, a current of dry air. The method is decidedly good, and when well managed, will prove a formidable rival to the vacuum pan. Its efficacy is more than equal, probably, to any work that may be required in this country (Trinidad). In working the pan, care must be taken to give the proper speed, and to charge only a few gallons at a time, and that only when the syrup has

reached the granulating point. With the first charge, a handful of good dry sugar may be mixed, to expedite the crystallizing process. The sugar is then brought (there being no danger of burning) to indicate a density of 44° Beaumé, and as the heat of the syrup may not even then be more than 160 F., the wheel must be stopped, and the temperature allowed to rise to 180° F. before striking. By the time the whole has run out, the sugar will have reached 182° F. About two inches deep of syrup should always be left in the pan, to prevent caramelization, and facilitate the crystallization of the succeeding strike, that is, the pan should not be entirely emptied till the last strike be run off." In whatever description of vessel the concentration of the syrup is completed, the same rule must be observed, to keep the temperature below 180° F., and then evaporate the water as quickly as possible, till it reach a density of 42 to 45° Beaumé, according to its purity. Practice is necessary to determine the exact moment for striking, which an experienced boiler can easily decide by appearances. When the strike is taken off, it should be maintained for a short time at a temperature of 100° to 184° F., in order to induce a perfect crystallization.

CHAPTER VII.

CRYSTALLIZATION AND CURING OF SUGAR—RECAPITULATION AND REMARKS.

THE crystallization of sugar is a most important process in the manufacture, and care should be taken in the formation of the curing house, to adapt it to the purpose for which it is required—the perfect crystallization and drainage of the sugar. The size of this room should be in proportion to the quantity of sugar intended to be made. It should be dry, well lighted, and furnished with means of artificially increasing the temperature, either with steam or by a stove. The method adopted in a hot-house could readily be applied to this purpose, and the temperature should never be allowed to fall below 100° F., occasionally it might be raised a little more. As there is no doubt that the solar light and heat would facilitate the crystallizing and curing process, the room should be well lighted from above, with thick plates of glass, similar to those used in the roofs of sheds at railway stations, which are not very expensive, and are as strong and less liable to injury than tiles.

If it is intended to syrup the sugar during drainage, it will be found most convenient to run it into moulds, of the usual conical form, made either of earthenware or metal, the latter being preferable, as less liable to breakage, occupying less room, and more easily handled. They must be ranged in rows over metallic gutters, kept scrupulously clean, which will convey the melasses (or rather syrup) to some convenient receptacle, which can be emptied and cleaned every day. It must be reboiled immediately, before any loss is sustained by the chemical changes which rapidly affect it; for it must always be kept in mind, that the melasses from sugar, manufactured as above described, contains only a small proportion of uncrystallizable matter, and is, in fact, the mother-water, from which the first crystallization has taken place, containing nearly two-thirds of its weight of crystallizable sugar, and only wants further concentration, at a low temperature, to give up the greater part of this sugar, at a subsequent crystallization. After the sugar is run into the moulds, which will be at about the temperature of 180° F., it must be slowly stirred once or twice, to disperse the crystals which are forming at the sides and surface equally through it, and to prevent a crust from gathering on the surface. When it has cooled down to 130° F. it must not be farther disturbed. After it has been in the moulds from 18 to 24 hours, the plugs must be withdrawn, and the melasses allowed to drain off; when the clear syrup can be passed through the sugar, as before described in the method of using Gaddesden's pan.

Dumas describes syruing as "the filtration through the sugar of a saturated syrup, at the ordinary temperature. As the syrup cannot dissolve the sugar, it chases before it the more highly coloured melasses, which darkens the superficies of the crystals, substitutes itself in the interstices, and then drains out in its turn, leaving the sugar comparatively bright. The conditions essential to the success of syruing are the following: 1. That the syrup should be sufficiently saturated with crystallizable sugar, to dissolve nothing in the filtration. 2. That its density be nearly the same, or only a little less, than what it is destined to replace,—too dense, it will percolate slowly; and too thin, it would slip past without carrying off the melasses adhering to the crystals."

This method of syruing is the same as is practised by refiners in clearing their loaves. The top or apex of the cone remains moist and discoloured. This is removed by cutting off the discoloured portion, in a turning lathe, which preserves the original conical shape of the loaf.

In boiling-houses, where it is not considered necessary to syrup the sugar, the most convenient vessels for crystallizing in are those which are successfully used in Guadeloupe, and are found sufficient for the requirements of estates making seven and eight hhds. per day. They are described as small zinc trays, about twenty-seven inches long, by twenty-six inches broad, and five inches deep, each holding about 60 lbs., and when full, can be easily handled by one man. They cost about 6s. 3d. each. When the

sugar has become solid in these trays, they are placed diagonally over zinc-lined gutters, the lower angle resting on the gutter, and leaning against one another so as to occupy as little space as possible. In this position the melasses rapidly drains off; and in a short time, if the temperature of the room has been kept up to the degree mentioned before, the sugar becomes perfectly dry, except the lower angle, which is knocked off, and can be reboiled with the melasses, and is ready to be packed in any convenient form for shipment. No loss is sustained on the voyage, as there will be no drainage; and indeed if it has been rendered very dry before packing, it will weigh more when sold in this country than when it leaves the curing house. Sugar being hygrometic, will absorb any moisture to which it may be exposed from the humidity of the atmosphere, and thus notably increase its weight, without any deliquescence taking place.

The melasses being reboiled from day to day as it drains from the sugar, will prevent the destruction of the large proportion of crystallizable sugar which, when *new*, it contains; and if it should not be thought necessary to syrup or blanch this secondary sugar, after crystallization it will afford an abundant supply of brown sugar for the refiners; and the uncrystallizable melasses from it can be all converted into rum, by being fermented with the refuse from the filters.

The temperature of the room in which the crystallization of sugar from melasses takes place should be higher than

is necessary for sugar of the first crystallization; and it would be better to have a separate apartment for this purpose, which can be kept at a temperature of not less than 110° F. and occasionally a good deal higher. There need not be so much care taken about the gutters for the preservation of the melasses from contamination, as, not being required for reboiling, it can be conveyed by leaden drains to the melasses cistern, to be afterwards used for distillation.

Every kind of sugar should be rendered perfectly dry before it is packed for shipment, that no loss may be sustained by deliquescence on the voyage. Hogsheads are very unsuitable packages for sugar. Boxes containing each from two to five cwt. would be more convenient, and would neither be so costly nor unwieldy as the hhd.; while they would be more conveniently packed away in the store, and easily carted from the estates to the places of shipment.

Having detailed a plain and convenient method of procuring the largest possible amount of sugar from the cane, I shall briefly recapitulate the most important points to be observed in the process, the details of which can be modified in many ways to suit particular circumstances. 1. To ensure the expression of the largest amount of juice from the cane by adequate machinery. 2. To raise the temperature of the juice to the boiling point as fast as it is expressed, and so prevent the destructive change which immediately commences in it when exposed to the usual temperature of the atmosphere. 3. That before the juice is submitted to evaporation, it should be freed by defecation

and filtration from the impurities contained in it, and be brought as nearly as possible to a pure solution of sugar and water. 4. That defecation, filtration, and evaporation to the density of from 28° to 32° Beaumé, follow each other with the greatest possible rapidity. 5. That after this point has been arrived at, the concentration should be completed at a temperature not exceeding 180° F., but if possible at 160° F., which can be accomplished most certainly in vacuo; but with ease, by proper skill and attention, in many of the other pans invented for this purpose. 6. That crystallization should be promoted by keeping the sugar for some time at a temperature of 180° F., that being the temperature most favourable for this operation; and that the curing house, or rooms in which the sugar is crystallized and drained, should be dry, well lighted, and provided with the means of artificially raising the temperature of the air contained in them. 7. That the melasses or syrup from the first sugars should be reboiled every day as fast as collected, as the salts and other impurities contained in it speedily effect a chemical change, which results in the total loss of a large proportion of the crystallizable sugar contained in it, and which, by a farther concentration, is readily procured. 8. That in all the above operations the most rigid cleanliness be observed; that the mill, the gutters, and sieves be all constantly purified by repeated washings with boiling water; that the defecating and evaporating vessels be always scoured perfectly bright; and that the drains or gutters which convey the melasses from the first sugars,

and the receivers in which it is collected, be emptied and washed every day.

If this system be generally carried into effect, the amount of sugar from the same quantity of canes can be doubled, and every estate now making 100 tons of sugar, could ship 200 tons of a better quality.

CHAPTER VIII.

DESCRIPTION OF THE METHOD OF SUGAR-MAKING USUALLY PRACTISED
IN THE WEST INDIES—LOSSES SUSTAINED BY ITS OPERATION—
CONCLUDING REMARKS.

I SHALL now proceed to detail the method of manufacture hitherto pursued in the West Indies, and which, with the exception of a very few individual cases, is at present universally practised. And in doing so, I shall indicate the imperfections of the system, and the losses sustained by its operation. In this description I shall confine myself to the most improved arrangements, where separate clarifiers are used, although the old method of defecating in the same range of boilers in which the evaporation and concentration is effected, is still in some places commonly practised. The two systems are precisely the same, the only difference being in the mechanical arrangement.

The juice is in most instances expressed in windmills, which by their rapid and irregular motion cause a vast loss by leaving a portion of the juice in the megass, as before pointed out. The liquor flows from the mill-bed (which is

composed of two gutters or shallow trays lined with copper or lead) into a wooden cistern or receiver, lined with lead, and placed within the mill, first passing through a strainer composed of a wooden box, the bottom of which is perforated with gimlet holes. A child or aged person is usually employed to keep this strainer and the mill-trays from being choked by the fragments of megass &c. which fall down from the rollers with the juice. This is done by thrusting a long cane or stick along the trays under the rollers, and as this is seldom changed, it, as well as the box strainer, becomes saturated with acid liquor, and cannot fail to hasten the development of acidity, and viscous fermentation in the passing juice. The impurities thus collected are removed in pails, and carried to the cattle or horse troughs. The liquor accumulates in the receiver until the clarifiers are ready for it, and when the mill is working rapidly it often remains a long time there before room is made for it in the boiling-house. It is conveyed thence from the mill, either in a long open gutter usually lined with metal, or underground by a leaden pipe. From the cold juice being so long in contact with these conduits, they are more or less coated with glutinous ferment, which assists the atmospheric action by rapidly inducing viscous fermentation. I have seen from this cause alone a rapid deterioration in the quality of sugar during a single day's work, and the taint being once communicated is not got rid of, as a portion of the liquor is usually kept in the boiling-house all night to cool the coppers, and this mixes

with the next day's liquor, and so on. The temperature of the atmosphere being usually about 80° F., which is that most favourable to the development of fermentation: the rapid deterioration of the juice, when exposed to its action, under such unfavourable circumstances, cannot be wondered at; and at this stage the first great evil is effected which renders the subsequent treatment much more difficult, and causes a certain loss of saccharine matter: creating in its place a substance which continues to act injuriously upon the remainder during the whole of the subsequent process.

After running into the clarifier, racking copper or simmerer, as it is variously designated, the temperature of the liquor is raised to about 140°, and it is then tempered; that is, milk of lime is added in sufficient quantity to cause a coagulation of the impurities contained in it. The sufficiency of lime required for this purpose is noted by filling a glass with the tempered liquor, and observing the separation of the flaky feculencies which are to be seen floating in the clear liquid. The separation of the coagulæ is made more or less perfect according to the judgment of the operator, as some kinds of cane juice will not bear a sufficient quantity of lime to effect this completely without discolouring the sugar. After a sufficient quantity of lime has been added to it, the liquor is smartly stirred with a ladle or other suitable instrument, and the temperature is raised until a thick scum gathers on the surface, on the cracking or bursting of which, as the liquid approaches the point of ebullition, the fire is withdrawn, and it is left for a

short time to repose; after which the clarified liquor is drawn off by a cock, and runs into the coppers, leaving the scum in the clarifier, which is then ready to be refilled from the mill receiver. After having been twice filled and emptied, the mud is cleared out before it is again filled. The clarified liquor as it runs into the coppers is not perfectly transparent, but has a cloudy appearance, little particles are observed floating in it, and it continues on boiling to throw up a further quantity of scum.

Upon the accuracy of tempering depends the success of the whole operation. If not sufficiently tempered the sugar refuses to crystallize, or forms a doughy, moist sugar, with a small grain, and if over tempered the liquor assumes a green colour, (from the particles of chlorophylle being dissolved by excess of lime,) and becomes red as it approaches concentration, giving a dark sugar with much melasses, and which has an unpleasant smell when in the hogshead. In all cases, a portion of the lime forms compounds with the sugar and the albumen, and the liquor, in consequence, loses some of its sugar in the scum thrown up during evaporation; a further portion of the sugar is rendered uncrystallizable, and adds to the quantity of melasses, which, in turn, is rendered unfit for reboiling into good sugar. The compound which the lime forms with the albumen produces a gummy liquid, which remains in the liquor, and when it is concentrated to syrup forms coagulæ, which renders it cloudy and opaque, and a portion of which remains in the sugar after curing. It is also

productive of injury of another kind, for as it begins to coagulate in the syrup, (at the heat of about 218° or 220° F.,) it sinks and adheres to the sides of the *tayche*, forming a crust, which raises the temperature of the boiling liquid, and induces caramelization, at the same time depriving the sugar of a portion of its carbon, (which is said to have the effect of rendering the grain of the sugar smaller.) The lime used in tempering is generally burned with wood, or under the coppers in contact with the ashes, and therefore contains carbonate of potash. Caustic potash is by this means generated in the liquor tempered with it, and deliquescent compounds are formed with portions of the sugar; the lime is also often slaked with liquor from the clarifier, thus forming a saccharate of lime to temper with in the first instance. Some persons add the lime to the liquor while cold, and this method is advocated by some planters as superior to hot tempering, upon what grounds I am ignorant.

The processes of evaporation and concentration take place in a range of copper boilers, placed over the same fire, the heat from which is to a great extent absorbed by the mass of brickwork which the peculiarity of their form renders necessary. They are usually five or six in number, the smallest of the range or *tayche* being immediately over the furnace, the flame from which afterwards acts upon the others in passing to the flue. The size of the coppers is progressively increased as they recede, the last being the largest, and it is often capable of containing nearly as much

as the clarifier. The clarified liquor runs first into this copper, and as evaporation proceeds, it is ladled into the others progressively until it arrives at the *tayche* where the concentration is completed. The liquor being drawn into these vessels after defecation, the fire is maintained as briskly as possible, and as in boiling the liquor continues to throw up much scum from its imperfect defecation, a person is stationed at each copper to remove, with a skimmer, the scum as it rises, and sometimes by brushing back the froth from one vessel to another, until it accumulates in the last, when it is removed. I cannot better exemplify this laborious operation than by quoting the words of E. Packer, Esq. in a communication to one of the agricultural societies of Barbadoes:—"Our old planters seemed fully alive to the necessity of removing this substance, as it rose in scum on the surface of the liquor in the *tayches*; and one of the points in which they were most rigid with their slaves was the scumming of the liquor. It is painful to recur to the means by which the boilers were made to accomplish this laborious process, but every one must remember that the liquor was not considered to have been perfectly cleaned until every boiler had his shirt sticking to his back with the perspiration from his body. Such means are fortunately not now at our disposal; but it seems to me that we have not looked to the necessity which still remains for thus cleansing the liquor, and I believe that if there is one cause operating more than another in producing that bad name which some of the

brokers in the mother country give to our sugar, it is the fact that our liquor is not properly cleansed."

The syrup is concentrated in the *tayche*, and the strike or skip is taken off at a temperature of from 234° to 238° F. In most cases this is effected by ladling it out of the *tayche* into a gutter which conveys it to the coolers. The operation of striking lasts two or three minutes, according to the size of the *tayche*. The last portion of the strike being necessarily most highly concentrated, and at the same time exposed to the most elevated temperature, not only receives much injury, but leaves a portion adhering to the *tayche* in the form of caramel, which increases the colour of, and otherwise injures the succeeding strike. In some cases a dipper is used, which is a copper vessel with a valve in the bottom, made to fit the inside of the *tayche*, into which it is lowered by a crane or other contrivance, and thus the whole of the sugar is at once removed. A small quantity is, under any circumstances, left adhering to the sides of the *tayche*, and is caramelized before it can be refilled with liquor. It is evident that the smaller the *tayche*, the more rapidly will its contents be concentrated, and the shorter will be the exposure of the syrup to the high temperature which is so productive of injury, and it has been found in practice, that the smaller the *tayche*, other things being equal, the better is the quality of the sugar. Some planters who remarked the injury done to sugar by the excessive heat generated by high boiling, endeavoured to remedy the evil by striking their sugar very

low, which certainly produced a superior quality of sugar, but at the expense of quantity; for the melasses not being reboiled, the portion of sugar held in solution by excess of water was lost, and the method was thus found to be unprofitable.

The conversion of clarified liquor into sugar, is simply effected by evaporation, and the successful issue of the operation depends upon the rapidity of its execution and the degree of purity the liquor has been brought to. It is evident from the fact, that sugar is soluble in certain proportions in water; that the farther the water can be evaporated without caramelization, the larger will be the amount of crystallized sugar procured from the strike; (provided the inspissation be not carried so far as to prevent the motion of the crystalline molecules;) but as this cannot be effected except at a low temperature, the system of concentration in the common *tayche* under the usual atmospheric pressure can never be successful.

On taking off the strike of sugar, (the time for which is determined by a granular appearance in the syrup which adheres to the back of a ladle on slowly withdrawing it from the *tayche*,) it is conveyed by wooden gutters to the coolers, which are large wooden trays about twelve or fourteen inches deep, and usually are capable of containing from half a hogshead to a hogshead of sugar. They are placed in that part of the boiling-house most exposed to the air, and at a convenient distance from the coppers. They are so disposed as to favour the passage of a current

of air over the surface of the sugar contained in them, which being thrown into each cooler in alternate strikes, has in each instance become hard before the next strike is thrown upon it. If it should not granulate and harden rapidly, it is repeatedly stirred with a turn stick to favour and hasten this condition. This stirring produces a confused and irregular *granulation*, the sugar being prevented from *crystallizing* by the agitation and rapid change of temperature.

After remaining in the coolers till sufficiently solid, the sugar is dug up with cutters and shovels, and carried in pails to the cask, into which it is thrown without any regard to temperature, but as is most convenient for expediting the operations of the boiling-house. It is generally very warm when casked, and, in consequence, much sugar which would have crystallized on cooling is drained off with the melasses, and some of it is deposited on the stancheons and in the cisterns as it cools.

The wooden stancheons upon which the hogsheads are placed to drain, are saturated with old melasses and acid ferment, and communicate the taint to all the fresh melasses which flows upon them, and the fermentation which is constantly going on in the cisterns speedily renders the melasses very unfit for profitably reboiling. The drainage of the sugar is also very imperfect, being much impeded by the irregularity of the crystallization, the injury caused by the rude manner of breaking it up in the coolers, and the rapid fall of temperature when exposed to the cold

atmosphere of the curing house, (which is usually the coldest and darkest place on the estate.) Much of the melasses is retained with the sugar, which has the effect of producing an unceasing delequescence, very much increased when exposed to the heat of the ship's hold. Veins and dark streaks and spots are also observable in the sugar, produced by the surfaces of the layers formed by the different strikes in the coolers. The melasses, as it leaves the hogshead, usually marks 37° Beaumé, requiring only a farther evaporation of 20 per cent. of water to bring it again to the crystallizing point, but being exposed to the free action of the atmosphere over the extended surface of the stancheons and drains, it loses a portion of its water, and deposits crystals of sugar which form nuclei for farther depositions as fresh melasses passes over them, till the melasses becomes poor in sugar, fermentation goes on in the cistern, acidity commences, and the crystallizing power is lost.

The above is a faithful description of the method at present almost universally practised in the West Indies, which I have merely detailed with a view of indicating the losses sustained by its operation, and of contrasting it with the more rational and profitable process before described; and when it is apparent what vast losses are sustained by the planters individually, and what an enormous quantity of sugar is annually sacrificed after the canes have been brought to perfection, which, if preserved, would by its

cheapness and abundance render the country independent of supplies from foreign sources, surely steps will be taken to adopt universally such improvements as will prevent its continuance.

The planters of slave-holding states are convinced that, even with their advantages of compulsory and continuous labour, they will not ultimately be able to maintain their position, unless they take advantage of every aid which science and skill can afford them, as is evinced by the large orders for machinery which our engineers and coppersmiths are executing for them. We read, that at the present moment an order is being executed for a single establishment in Cuba for machinery to the amount of £17,000, and I have myself seen many large orders in progress of construction. Do not these facts speak volumes? Do they not show clearly that these men are looking forward to the time when wasteful and inefficient methods of manufacture will not advantage them, and that they are availing themselves of their temporary prosperity to make preparations for the struggle which they foresee, a struggle in which only skill and energy, directed by science, can be successful.

The PUBLISHERS have added the following extract from the *Glasgow Herald* of October 11th, 1850, containing some important improvements in the apparatus for manufacturing sugar:—

NEW SUGAR-MAKING MACHINE.

On Friday, last week, we were invited by Messrs. Neilson, Hyde Park, to see a new sugar-making machine, just finished at their works. This machine, which is the patented invention of Mr. Edward Beanes, who is the representative of the Messrs. Neilson at Havana, is to be erected on the estate of his Excellency the Count of Penalver, one of the most extensive sugar planters in the island of Cuba.

In constructing this machine, much attention has been paid to the external appearance of the structure. In design, it is not unlike a miniature circular temple, such as are represented in pictures of Eastern life and manners, known as praying temples; and one would be ready to conclude that Mr. Beanes, the inventor, had confined himself as much to the exterior graces and symmetrical proportions of his invention as to its utility for the purpose to which it is to be applied. A close examination of the apparatus soon shows that every portion of the machine has its separate and indispensable use, and that the highest utility has not been sacrificed for the attainment of architectural beauty. This machine is a good example of how available iron may be made for elegant and useful purposes.

The apparatus is, as we have said, circular. The circle is twenty feet in diameter at the base. From the base spring six large fluted doric columns, these columns are sixteen feet in

height. Round the top of the columns there runs a cornice or entablature. Within the outer columns there are four other columns, the same in design as the outer ones, which support the pan or boiler. The boiler rises to a height of two and a half feet above the entablature, making the whole structure eighteen and a half feet in height. The boiler, with its cover, makes the cupola-like top to the erection, preserving and completing the likeness to an eastern temple, which we have already mentioned. The operator stands on a platform, which is railed in round the top and between the outer columns, where he has the entire machinery immediately under his eye. What we have said will give some idea of the form of Mr. Beanes' invention. We will now, as briefly, attempt a description of the mechanical uses of the various portions of the machine, but which, from the want of diagrams, must necessarily be only partially intelligible. And, first, we may mention that one great drawback in Cuba, is the want of a sufficient supply of water. Mr. Beanes turned his attention to provide against this want, and the result is the machine in question. So scarce is water throughout the island, that as Mr. Beanes informed us, in some places, there is not as much as would suffice to work a steam engine. This new apparatus, by its own action, generates as much water as is necessary for the process of sugar-making. A large portion of the erection is made available for the one grand purpose, namely, the condensation and economy of the precious element. Suppose, then, that the cane juice is put into the vacuum pan or boiler, the vapour which is thrown off by evaporation is conducted by four copper tubes to the entablature, which is tubular, and thence through an immense series of tubes which are contained in the six outer columns. It will at once be evident that the steam from the vacuum pan is being thus reduced in temperature and condensed. The condensation is further aided by a supply of cold air which is impelled by a steam engine, of peculiar construction, through various parts of the machine. The air is cooled

by being drawn from a deep pit beneath the basement of the apparatus. In its course the vapour is exposed to a surface of 2200 square feet of surface, upon which the injection water, brought to a low temperature by being passed in a shower of minute drops through a current of air, is kept constantly playing. We mentioned the four interior columns which support the vacuum pan; two of these are used as overflow pipes. One peculiarity in the arrangements of this machine consists in a particular construction of valves and receivers, by which all danger of interrupting the process of evaporation by overboiling is anticipated and provided against. The manner, also, of exposing the steam-heating surface within the boiler is novel, and will be more effectual than the usual method, in so far that a greater amount of evaporating surface is obtained, and at a much lower degree of heat. The vacuum is produced by three pumps with metallic piston-valves, connected with a wrought-iron three-throw-crank driven by a steam-engine of a very beautiful construction, which is peculiarly arranged for the purpose. The vacuum pan, with its pumps, connections, &c., is perhaps the most complete piece of mechanism which has yet been turned out of any establishment for a similar purpose, and is finished in a most elegant and tradesman-like manner in all its parts. Besides the apparatus we have described, two other steam-engines were in full operation at the same time. These were to be used for working the mills for crushing the sugar canes. The cane-mill, attached to one of the engines, is a most gigantic and ponderous piece of machinery. It is composed of three enormous rollers, which are worked by wheels, and must have an enormous crushing power. This will be evident when we state that the mill, without its gearing, weighs no less than forty tons. This, we believe, is the heaviest and largest machine which has ever yet been made for crushing canes. We cannot conclude our necessarily imperfect notice of these interesting machines without a word of commendation to the excellence, strength, and elegance of the workmanship, which

reflects the highest credit on the taste and ingenuity of the Messrs. Neilson. If not already on board; they will be immediately shipped for Cuba, whither Mr. Beanes, the ingenious inventor, will accompany them to superintend their erection. We have no doubt of the value and success of the invention, from the circumstance, that Mr. Beanes, besides being a practical engineer, has, from a twelve years' residence in Cuba, made himself fully acquainted with all the details of sugar-making.

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