AN ACCOUNT OF

Various Experiments

FOR THE PRODUCTION OF NEW AND DESIRABLE

GRAPES,

AND A DESCRIPTION OF

FORTY VARIETIES

OBTAINED BY

HYBRIDIZATION.

BY
GEORGE HASKELL.

IPSWICH, MASS.:
1877.

EXPERIMENTS.

In offering these vines for sale, it may be interesting to grape-growers to know the various methods and labors by which I have sought to obtain new varieties: it may also be a caution and great help to others engaged in similar efforts, to know of the many failures and meagre success of such labors.

The aim of all my efforts has been to obtain vines which would bear our winters, be free from mildew and other disease in summer, and bear good fruit which would ripen in this section. These efforts commenced many years ago, under these circumstances:—On reading the Treatise of Mr. Prince on the Vine, soon after it appeared, in 1830, I got interested in the subject and determined I would have a vineyard. In the ardor and greenness of youth, I bought two hundred Isabella vines of J. B. Russell, who then kept an agricultural store in Boston, and two thousand cuttings of the same kind of Mr. Samuel Pond, of Cambridge. These were planted and tended with care and expectation for several years, but I never obtained a drop of wine or a peck of ripe fruit from the whole of them.

Finding the Isabella would not succeed in our climate, I began the search for a good native, in the swamps and woods of this region. Whenever I heard of a wild vine bearing fruit called good, I invariably visited it, and I have travelled many miles, and for several years, through the swamps, woods, and morasses of this section, in quest of a grape worth cultivating. Some, of course, were better than others, and all that were better or earlier than the general run, were removed to my own grounds; but they did not improve, or were hardly as good, when grown in the warm, dry soil of a garden.

I then began to plant the seeds of these best natives, and continued to do so for three generations of vines, without obtaining, out of many thousands thus raised, a single fruit that I regarded worth propagating, and only a few of them have been preserved; but the earliest and best of native vines, thus obtained, have been used in crossing with the foreign.

Simultaneously with these efforts, I raised many hundred vines from seeds of different foreign grapes. These seeds were planted under glass, and the vines remained in the house two years, when they were removed to the open air. None of them proved healthy or would bear our winters. Some of them lived to bear fruit for a year or two, but they all died in a few years, though well covered every winter.

I then sought to obtain better fruit by grafting the native upon the foreign, and planting the seed of the native, thus grown upon the foreign root; but I could not discover any improvement in the fruit of the seedlings grown from such seed. I also sought to obtain hardihood of vine, by grafting the foreign upon the native and planting the seed of the foreign thus grown upon the native root; but the vines of such seedlings proved no hardier than seedlings from a foreign, ungrafted vine. In neither case did the stock appear to have any influence upon the character or fruit of the vines grown from seed of the graft, nor were such vines different from seedlings of the same species, when grown from seed of ungrafted vines.

I then tried to modify the fruit of seedlings through the agency of the foliage, and as soon as the fruit was formed on each species I inarched the new shoot of the other species into the shoot bearing the cluster just above the fruit. When the union of the shoots was complete, in about two weeks, I cut out the shoot proper to the fruit at the point of union and took off all the foliage on that shoot below the cluster: thus leaving the fruit with no foliage but that of the other species to nourish and mature it. White grapes were thus grown under the foliage of black grapes, and black under the foliage of white, and each retained its proper color, though the texture and quality of the fruit seemed to be changed by the alien foliage. The foliage of the foreign was thus placed over the fruit of the native, and the foliage of the native over the fruit of the foreign.

The seeds of fruits thus grown, were planted for several years, but the result was a great disappointment. I did not find such a decided effect as I expected. The vines from the seed of foreign fruit, thus grown, were not so hardy or healthy as I desired, nor was the fruit of native seedlings, thus grown, good enough to be propagated. Perhaps the latter, had they been tried a few years longer, might have improved, and farther south the former might have grown successfully; but, unfortunately, none have been preserved for such further trial.

My next method of seeking for the desired fruit was, by inarching the new shoot of the foreign upon the native, and of the native upon the foreign, as soon as the fruit was formed, both below and above the section of the cane bearing the cluster; and as soon as the union was complete, the cane bearing the cluster was severed from its own root and deprived of all its leaves; thus having the fruit of each species, with about three inches of its cane, grown and matured upon the root and under the foliage of the other species. I hoped some of the seed, thus grown, would produce vines possessing the desired qualities. (A full and more particular account of this process was published in the Country Gentleman, in September, 1863.) After laboring for years in this method, the vines thus obtained were abandoned as worthless. I now see the folly of my impatience in rooting them up after trying their fruit for only one or two years. Indeed, I should now regard vines, thus obtained, as of the highest interest, affording, as they would, some evidence of the influence of an alien root and leaf upon the offspring of seed thus matured. A few of the vines, thus obtained, were grafted near the ground, and I am trying to start shoots from the roots, to restore the original vine to view.

Thus baffled again, in my efforts to obtain the desired fruit, I began to cross-fertilize the flowers, foreign with the native and the native with the foreign, using many varieties of each species, of different sizes, colors and flavors in the fruit, and having differences in the form and other characteristics of foliage

This method has been pursued for fifteen years, and more than eighty different crosses have been effected, counting the second crosses, between the half-bloods, and of the half-blood back upon the original species. During the last ten years these crosses have not been made at random, but vines possessing some desired qualities, have been selected for union with other vines possessing other desired qualities, in the hope of uniting all such qualities in one fruit and vine. More than a thousand seedlings have been thus produced; several of them have borne fruit for eight or ten years, many of them for three to five years, and a few have never fruited, though not, organically, infertile. A docket has been kept of all these crosses, and of each vine thus produced, in which is noted its parentage, and habits of vine and qualities of fruit, during its whole existence.

The varieties now offered were thus obtained, registered and tried, and their qualities, as thus ascertained in this unfavorable part of the country, are correctly stated.

In selecting the fruit that appeared worthy of propagation, I have not preserved the vine when the fruit retained too much of the characteristics of the native parent. If it was too sour, too hard in pulp, too small or too foxy, or if the cluster was small, or much broken, or irregular in form, or if the fruit shook easily from the stem when ripe, I have thrown the vine away. Since then, I have seen so much improvement in the fruit and cluster, after the vine had ~~some~~ borne fruit for a few years, that I regret my conduct in this respect very much. I think some of those destroyed would have outgrown the defects for which I condemned them, and might have proved to be some of the best.

In selecting them for hardihood, I have left them for the winter to kill and weed out those constitutionally too tender to survive it; as I have never laid them down or covered them, even in this severe climate. In selecting them for healthiness, I have discarded and thrown out all those generally affected with mildew, and those occasionally affected with it so much as to prevent the ripening of the fruit. Some of the best fruits, however, have been retained, though the vine is occasionally, and to some extent, subject to its attack, as they may be entirely free from it in a dryer atmosphere, or farther from the sea-coast. In selecting them for early maturity, I have not condemned them altogether, because they failed occasionally to ripen here, if they possessed other required merits. Several such have been ripened under glass in a cold-house, and it then appeared that, with a summer a few weeks longer, or more steadily warm than ours, they were surpassed by few of the foreign grapes in size, beauty or flavor; notably was this true of Three, Three-Twenty-Five, Three-Eighty-Seven, and Four-Twenty.

I have thus briefly stated the different methods by which I have tried to obtain the desired grape, and some of the repeated and diversified experiments made for that purpose. These experiments have been carried on more than forty years—not a year having passed during that long period, in which I have not obtained and planted the seeds of native and foreign fruit, modified, lately, I had hoped, by the artificial use of nature's processes. This effort has not been omitted even when I was busy with professional cares and occasionally charged with official duties, nor on account of any trouble or expense to which I might thereby be subjected. The result has been very interesting, and partially successful; but how far successful, can only be determined by a full and thorough trial in other sections of the country, better adapted than this to the cultivation of this valuable fruit.

I am sorry the success has not been more obvious and decided; but, thinking it will be a long time before any other individual will be so unwise as to spend his money, time and thought in such efforts, or will do so with a better chance of success, I have concluded to offer to the public the fruits of these labors, such as they are. I had hoped to obtain a reimbursement of my money-outlay in this matter, but see no chance for even that. The nurserymen will not buy the stock of any of them, or even take them to propagate, until there is a call for them—and there will not be a call for them until they are generally known; and if distributed so as to be generally known, the originator is *minus* the whole undertaking. Whether I obtain any pecuniary recompense for the products of these labors, may be a question of justice; but it is not by any means a matter of necessity with me. I hope the fruits obtained will be a benefit to the public, and that the future will show them to be of great value to the country, in both an economic and commercial aspect.

I shall exercise the right of an author in giving them names, and shall preserve the numerical names now affixed to them. Such names are perfctly distinctive, are easily remembered, and can be briefly expressed in figures upon a plan, tag or order.

It may be objected that I am sending out too many varieties,—that it will confuse and perplex purchasers. But this distribution of varieties is only tentative; not that it can be desirable to propagate and multiply largely so many varieties in any locality. These have been selected, after years of trial from more than a thousand seedlings, of different crosses, and every one was selected because it possessed, when grown here, more than one desirable quality of vine or fruit. How they will thrive in other localities can only be known by trial; and it is to obtain such trial, and the selection of the best for each section that so many are offered. I also desire to have so many of these seedlings taken for trial in other sections, because I do not believe we shall ever obtain a variety that will be the best and most valuable in all sections. No such single variety is known in Europe, where the differences in soil and climate are less than in this country, and there is no reason to expect such a variety here. Another advantage of this distribution of many kinds will be, that seedlings of these hybrids will be obtained in other sections from a greater variety, in parentage, and with a better chance of finding among them vines adapted to those sections, and, quite likely, bearing better fruits than those yielding the seed.

Again:—no one variety will suit all palates best, either as fruit or for wine. In submitting these fruits to the most experienced and competent judges of grapes, I have been surprised at their diversity of taste and choice. They would all agree, generally, upon the best ten or twenty ; but if asked to designate the best two, or three, or five, they would differ widely, each having a preference for the flavor, texture, or comparative sweetness of a particular and different grape. Of course, to meet these different tastes, it is well to have a number of varieties of differing qualities propagated and tried. It might be supposed, from the similarity in many of the descriptions given, that the fruits were much alike. But it will be found that those much alike in form, color and other characteristics which can be stated in language, are yet quite different in flavor, taste and relish.

Another reason for the trial of so many kinds, is the hope that some of them, if planted in a soil suited to their native parent, will be safe from the attack of the Phylloxera. It will be observed, that most of the vines described, are from crosses with what is popularly called the Fox grape—but accurately it is the *Riparia*—a species which is found generally, in a wild state, only in swamps and on the banks of streams. The *Vulpina* and *Labrusca* are only other names for varieties of the same species, and they do not accurately describe any species, as the pungency on the lips and the fox odor, are not uniformly found in the fruit of either of them.

Recent experiments in France have shown that the most effectual eradication of the Phylloxera was by flooding the ground, and thus drowning the insects. As the *Riparia* of this country flourishes, and really does best in wet bogs and meadows, even when the roots are immersed in water all winter and the soil is saturated all summer, may we not expect that this trait will prevail in some of these hybrids and make them almost proof against the Phylloxera, especially if planted in such wet soils ? I shall place them in such soils and localities, and hope others will do so too, that the experiment may be fairly tried.

The belief that these grapes are worthy of distribution and trial, is strengthened by the judgment of many competent persons to whom I have sent the fruit. These opinions of others, however, have been formed and expressed, from an inspection and trial of the fruit only, and without any knowledge of, or reference to, the qualities of the vine, except, perhaps, from a general knowledge such persons may have of the ungenial part of the country in which the vines have been raised and fruited.

The following are the opinions of some of the gentlemen to whom the fruit has been sent.

In October, 1869, I sent several varieties to Marshall P. Wilder, which he, in company with Robert Manning, examined and made notes of as follows :—

295. "Sweet to the skin; pulp rather tender, vinous, sprightly; color dull amber reddish; a considerable improvement on the native."

300. "Same color, similar constituents, but leaving a rough, astringent taste at the skin."

309. "Like 300, but acidity in place of roughness."

325. "Smaller bunch and berry, sweeter, rather hard pulp, sweet and rich."

387. "Larger bunch; color dark and dingy; hard pulp; sprightly and good; winy."

126. "Dark amber; the ripest ones chestnut color; appears to have passed its maturity."

334. "Sweet and tolerably rich, but pretty foxy, leaving considerable astringency in the mouth."

339. "Apparently later, not so well colored, but having a Catawba smack."

346. "Berry largest and most foxy of all; chestnut color; a slight remove from the native."

The next year, at the request of Mr. J. B. Garber, of Columbia, Pa., I sent eighteen varieties to him, which, in company with three gentlemen of that neighborhood, he examined, and they sent me a detailed report of their opinion of them. I suppose they furnished the following account of them, which I find in the "Lancaster Farmer," November, 1870:—

"Then we have received a box containing eighteen varieties, all hybrids, from Mr. G. Haskell, of Massachusetts. These are all new, none of them yet out of the hands of the originator. Some of them were somewhat damaged by being delayed on the way. We, in company with several other grapists, on testing and tasting these new grapes, fully agreed that they were very promising. Should these varieties, or some of them at least, improve by being grown in our latitude, or still further south, as the Concord is known to have improved, then these new ones are certainly worth looking after. Mr. Haskell is a persevering experimenter, having already in 1869 fruited between six and seven hundred seedlings, of which he has selected twenty of the best for further trial, and has over two hundred fruiting for the first time this last season. These many varieties are the product of more than thirty crosses, and he is still continuing his experiments. Of course, among so many there will be a large portion that will probably be no improvement on older sorts; yet he can hardly fail of producing some very superior varieties."

Three years later, in 1873, I sent nine varieties to the editors of the "Country Gentleman," and their opinion of them was stated in that paper for October 23d, as follows:—

"The grapes came in fair order—a little the worse for time and transportation, but so that we were able to judge well of their quality. The collection consists of nine seedlings, but as we are not told from what varieties they are crossed, we are unable to judge how successful the experiments have been by way of improvement on the parents. On comparing the flavor with the Concord, we find at least two-thirds of better flavor, with a strong tendency towards sweetness. Nos. 36, 74, 325, 371 and 387 are quite sweet, and of very fair quality, so far as we can judge from so imperfect a trial. The others are not so good, and one or two rather poor. Of the growth, hardiness or productiveness of the vines, we have no means of knowing. We have thus given our opinion, as these grapes appear to us—an opinion liable of course to revision on a better opportunity for judging."

In 1874, I sent six varieties to the editors of "Colman's Rural World," in St. Louis, and in that publication for November 14, 1874, the following statement is made in regard to them :—

"The grapes came to hand in good condition, showing that our correspondent knows how to pack such things. No. 371, bunch small, berry medium, round, dark red ; thin skin, small seeds, but plenty of them ; pulp soft, sweet and pleasant.

No. 325, Large bunch, shouldered ; berry oval, a little above medium in size ; thin skin, melting pulp ; very rich and sweet.

No. 387, Bunch medium ; berry do, slightly oval; thin skin, soft pulp, sweet, spicy and rich in flavor ; pale red in color.

No. 36, Bunch and berry medium ; round, dark red ; first-rate.

No. 295, Bunch medium ; berry a little above round; pale greenish red ; skin thin; pulp dissolving, sweet and pleasant; very good, we would call it.

No. 74, Bunch medium ; berry large, oval, black, with a fine bloom upon it after travelling fifteen hundred miles ; skin thin ; pulp soft and melting, sweet and aromatic ; most valuable of the lot, in our opinion. There is a touch of Black Hamburg in this last that pleased us very much. If these grapes improve when grown here, as usual, we look for some valuable additions when they are set out. We should like a few grapes of each to try them, and will most likely be able to report by the fall of 1876.

All the Rogers' hybrids are so much improved in size of bunch and in quality, when grown here, that they would hardly be taken for the same variety. This we would expect of Mr. Haskell's grapes also."

A number of varieties were sent that same year to the editor of the "Massachusetts Ploughman," and he commented upon them in that paper as follows :—

"We acknowledge with pleasure the receipt of a variety of seedling grapes from George Haskell, Esq., of Ipswich. Some of them were of excellent quality and worth propagating. No. 74 was especially fine it seemed to us, though it was perhaps fresher and more in its best condition as to ripeness. Some of the samples were a little over ripe."

The same season they were sent to Mr. Meehan, of the "Gardener's Monthly," and he expressed his opinion thus, in Nov., 1874:

"GRAPE SEEDLINGS FROM MR. GEO. HASKELL, Ipswich, Mass.

These are some of the best we have seen, and when the high northern latitude is considered, show how marked has been grape improvement of late years. There are among them black, white and red bunches; and some of the bunches of considerable size."

Another parcel was sent to the editors of the "Country Gentleman," and in that paper for November 5, 1874, they are described as follows:—

"Nos. 74 and 118 are black grapes, of very tender skin, little pulp, and sweet and good flavor. The first named appears to be an excellent grape. But none are large and showy enough to produce 'a sensation.' Nos. 295 and 387 are light brown, quite sweet, and hardly so good as the black ones."

In the same year, 1874, seven varieties were sent to Wm. Saunders, Superintendent of the Government Experimental Grounds, at Washington, and he sent me the following report upon them, which he consents to have me publish. In consenting to have me publish this report, however, he adds:—"I have long ago learned that no one can tell anything about the general value of a grape by simply testing a bunch of its fruit; and that opinions formed upon such slight acquaintance are of little value." His report of the fruits was as follows:—

No. 325. "A very fine flavored grape, and very large, fine looking bunch."

No. 36. "Bunch of fair size; berries spicy in flavor; drops readily from the bunch."

No. 74. "As fine looking as a Black Hamburgh, and about as good in flavor; really a splendid acquisition."

No. 387. "This is, to my notion, the best, and most delicately flavored grape of the number; a superior table fruit."

No. 371. "The smallest of the lot, both in bunch and berry, and not conspicuously good."

No. 118. "A very pleasant grape, somewhat tart; perhaps not quite as ripe as it might be."

No. 295. "Very like 325 in flavor; bunch not so large, but good size notwithstanding."

"These six grapes are, perhaps, finer than any six named hardy grapes that are now in cultivation."

The next year, 1875, six varieties were sent to Marshall P. Wilder, and he made the following notes upon them, which I am permitted to use:—

No. 74. Black; berries large, oval; thick bloom; juicy, sweet, sprightly; pulp tender; seeds large; one of the best natives we have ever tasted."

No. 420. Black, medium size, slightly oval; skin thick, thick bloom; pulp firm; rich, vinous, sprightly; holds on well; very good."

No. 118. "Black, round, thick bloom; skin not so thick as last and seeds larger; otherwise much the same."

No 36. "Resembles the Catawba in many respects, with thicker bloom, and holds on well."

No. 387. "Chestnut color ; thin bloom, round, medium size ; thin skin; pulp rather tough, very sweet and rich; adheres strongly."

No. 325. Color like the last, with dots like the wild type ; medium size ; thin bloom ; sweet; juicy; pulp rather tender; seeds small; sprightly; vinous near the skin with foxy aroma."

"On the whole, this lot impresses us much more favorably than on former occasions, showing the influence of hybridization in breeding out the native aroma, while yet more may be done in the way of producing pulp more tender."

Mr. Wilder submitted these varieties to the examination of the Fruit Committee of the American Pomological Society for Massachusetts, and they report thereon (page 119) as follows:—

"Mr. George Haskell, of Ipswich, has for several years been engaged in hybridizing the grape, and has produced a large number of varieties, among which are several of excellent quality. Of six varieties presented by him the present season, five were entirely free from the peculiar foxy flavor of the native grape."

Ten varieties were also sent to Dr. Robert Hogg, editor of the London Journal of Horticulture, and the following mention is made of them in that publication for Nov. 11, 1875 :—

"We have received from Mr. George Haskell, of Ipswich, Mass., a collection of ten varieties of SEEDLING GRAPES, raised by crossing the native *Vitis riparia* with European varieties, and *vice versa*. These are very curious, and some of them are very excellent varieties. The influence of the cross is very apparent in all of them, and it is quite possible that in this way varieties may be raised that will ripen out of doors in this country. Even in this unfavorable season Admiral Hornby has ripened one of the American Grapes at the Cottage, Knowsley, and Mr. E. J. Beale has been equally successful at Twickenham. One or two varieties which have the Black Hamburgh and White Chasselas for their male parents are very good indeed, and have a flavor which is quite peculiar."

Similar opinions have been expressed by many grape-growers in distant parts of the country, to whom the grapes have been sent during the last eight years, but I have not deemed it worth while to ask permission to publish their communications to me, and I do not feel at liberty to do it without their consent. These opinions are not quoted to prove that these grapes possess every desired quality of fruit and vine ; but only to confirm the belief that they deserve attention and trial.

Notwithstanding these flattering testimonials of the qualities of these fruits, I have not been able to obtain any terms for the propagation and distribution of the vines, except to give them away to nurserymen and others. I was not disposed to do this, and I have propagated some of the best and most promising varieties, in suffi-

Select Varieties.

Repeated trials, during the last few years, have enabled me to select, from many thousand hybrid seedling grape vines, the best Twelve, viz.: two black, two red and two light amber, having some of the musky flavor, which is much liked by some persons; and two black, two red and two light amber entirely free from that flavor.

The first six described have a little of the musky flavor, viz.:

BLACK.

THREE. **Parentage:** seed of Amber Fox fertilized with pollen of Black Hamburg. **Fruit:** black, round, very large, skin thin, pulp tender, sweet, flavor excellent, rather late. **Cluster:** very large, shouldered, compact. **Vine:** very vigorous, hardy, very productive, in some localities and seasons slightly affected with mildew.

THREE-SEVENTEEN. **Parentage:** seed of large Amber Fox fertilized with pollen of White Chasselas. **Fruit:** black, oval, large, skin thin, pulp tender. **Cluster:** large, shouldered, not very compact, of regular form. **Vine:** vigorous, hardy, healthy and very productive.

RED.

THREE-TWENTY-FIVE. **Parentage:** Seed of Amber Fox fertilized with pollen of White Frontignan. **Fruit:** deep red or maroon, with little bloom, oval, medium, skin thin, pulp tender, sweet and rich, flavor good. **Cluster:** large, regularly shouldered, close but not crowded. **Vine:** vigorous, very productive, bears the winter perfectly, but is sometimes attacked with mildew.

THREE-EIGHTY-SEVEN. **Parentage:** seed of Amber Fox fertilized with pollen of White Frontignan. **Fruit:** dark amber, round, medium, skin thin, pulp firm and rather tart, flavor excellent, like Frontignac, rather late. **Cluster:** large, shouldered, very compact. **Vine:** very vigorous, very healthy and productive.

WHITE OR LIGHT AMBER.

THREE-FORTY. **Parentage:** seed of large Amber Fox fertilized with pollen of White Frontignan. **Fruit:** nearly white round, large, skin thin, pulp tender, excellent flavor. **Cluster:** very long, without shoulders, close but not crowded. **Vine:** vigorous, hardy and productive, sometimes and to a small degree affected with mildew.

TWO-NINETY-FIVE. **Parentage:** seed of White Fox fertilized with pollen of White Chasselas. **Fruit:** very light amber or white in the shade, round, large, skin very thin, pulp tender, sweet, flavor good. **Cluster:** large, shouldered, compact. **Vine:** vigorous, hardy, healthy and enormously productive, producing clusters from the eyes at the base of the shoot.

The following described six are entirely free from the musky flavor, viz.:

BLACK.

SEVENTY-FOUR. Parentage: seed of Black Fox fertilized with pollen of Black Hamburg. **Fruit:** black with a heavy light-blue bloom, oval, very large, skin thin, pulp tender, sprightly and vinous, flavor good, early. **Cluster:** medium, small shoulders, compact but not crowded, holds the fruit well and keeps late. **Vine:** of medium vigor, short-jointed, hardy, very productive and healthy.

FOUR-TWENTY. Parentage: seed of Black Hamburg fertilized with pollen of Black Fox. **Fruit:** black with a blue bloom, oval, very large, skin very thick, pulp rather hard and acid, flavor peculiar, spicy and delicious, rather late. **Cluster:** large, irregularly shouldered, broken and open. **Vine:** very vigorous, hardy and healthy.

RED.

THIRTY-SIX. Parentage: seed of Amber Fox fertilized with pollen of Black Hamburg. **Fruit:** dark red with lilac-colored bloom, round, medium, skin thin, pulp firm, sweet, flavor good. **Cluster:** large, shouldered, open, of regular form. **Vine:** vigorous, hardy, very healthy and productive.

THREE-HUNDRED-NINE. Parentage: seed of Amber Fox fertilized with pollen of White Chasselas. **Fruit:** dark amber, slightly oval, medium, skin thin, pulp tender, excellent flavor, early. **Cluster:** good size, small shoulders, open. **Vine:** vigorous, hardy, very healthy and productive.

WHITE OR LIGHT AMBER.

THREE-SEVENTY-THREE. Parentage: seed of small Amber Fox fertilized with pollen of White Frontignan. **Fruit:** white or light amber, round, large, skin thin, pulp tender, excellent Frontignan flavor. **Cluster:** large, large shoulders, not very close. **Vine:** of medium vigor, very hardy, healthy and productive.

THREE-HUNDRED-SIX. Parentage: seed of large Amber Fox fertilized with pollen of White Chasselas. **Fruit:** light amber, round, small, skin thin, pulp tender, very good and very early. **Cluster:** small, slight shoulders, compact. **Vine:** medium vigor, small firm wood, hardy, moderately productive.

The above are for sale at One Dollar per vine; any six for Five Dollars or the twelve for Ten Dollars, delivered at Express office in Boston. Remit with order by registered letter or postal order on Salem, Mass.

IPSWICH, MASS., 1879. GEORGE HASKELL.

cient numbers to supply a few cultivators with an assortment of thirty kinds, embracing the best of different crosses. I do not in tend to multiply or propagate them any farther than may be necessary to secure a distribution and trial of them. Several of those last described, promise well,—a few of them appear *very* good—but they have not borne fruit long enough to determine their merits, and I have not propagated many from them.

Such of them as prove good, or worthy of trial elsewhere, will be sent, if desired, at the same rate per vine, to all who now purchase thirty varieties.

If any grape-grower or nurseryman desires to purchase such an assortment of thirty vines, I shall be glad to supply him with them at a very low price, considering their cost to me ; if they are not desired it may excite my regret, but it will do me no harm ; nor, indeed, would it were I to annihilate the whole brood of vines, as I, at times, have been almost tempted to do.

GEORGE HASKELL.

IPSWICH, Mass., Jan., 1877.

DESCRIPTION OF VARIETIES.

THREE. **Parentage:** seed of Amber Fox fertilized with pollen of Black Hamburg. **Fruit:** black, round, very large, skin thin, pulp tender, sweet, flavor excellent, rather late. **Cluster:** very large, shouldered, compact. **Vine:** very vigorous, hardy, very productive, in some localities and seasons slightly affected with mildew.

THIRTY-SIX. **Parentage:** seed of Amber Fox fertilized with pollen of Black Hamburg. **Fruit:** dark red with lilac-colored bloom, round, medium, skin thin, pulp firm, sweet, flavor good, free from foxiness. **Cluster:** large, shouldered, open, of regular form. **Vine:** vigorous, hardy, very healthy and productive.

SEVENTY-FOUR. **Parentage:** seed of Black Fox fertilized with pollen of Black Hamburg. **Fruit:** black with a heavy light-blue bloom, oval, very large, skin thin, pulp tender, sprightly and vinous, flavor good, no foxiness, early. **Cluster:** medium, small shoulders, compact but not crowded, holds the fruit well and keeps late. **Vine:** of medium vigor, short-jointed, hardy, very productive and healthy.

ONE-EIGHTEEN. **Parentage:** seed of Black Fox fertilized with pollen of Black Hamburg. **Fruit:** black, little bloom, round, large, skin thin, pulp very tender, flavor pleasant and sprightly, no foxiness. **Cluster:** medium, not shouldered, open. **Vine:** vigorous, hardy and very healthy.

TWO-TWENTY-FOUR. **Parentage:** seed of Black Hamburg fertilized with pollen of Pigeon. **Fruit:** black, round, medium, skin thin, no pulp, rather tart, colors early but improves by hanging late. **Cluster:** very large, very large shoulders, close but not crowded. **Vine:** very hardy, healthy, vigorous and productive.

TWO-THIRTY. **Parentage:** seed of Black Hamburg fertilized with pollen of Pigeon. **Fruit:** black, round, small, heavy bloom, skin thin, no pulp, tart, colors early but should hang late. **Cluster:** very large and heavy, small shoulders, long and very compact. **Vine:** very healthy, hardy, vigorous and productive.

TWO-NINETY-FIVE. **Parentage:** seed of White Fox fertilized with pollen of White Chasselas. **Fruit:** very light amber or white in the shade, round, large, skin very thin, pulp tender, sweet, flavor good, a little musky. **Cluster:** large, shouldered, compact. **Vine:** vigorous, hardy, healthy and enormously productive, producing clusters from the eyes at the base of the shoot.

THREE-TWENTY-FIVE. **Parentage:** seed of Amber Fox fertilized with pollen of White Frontignan. **Fruit:** deep red or maroon, with little bloom, oval, medium, skin thin, pulp tender, sweet and rich, flavor good with a very little foxiness. **Cluster:** large, regularly shouldered, close but not crowded. **Vine:** vigorous, very productive, bears the winter perfectly, but is sometimes attacked with mildew.

THREE-EIGHTY-SEVEN. **Parentage:** seed of Amber Fox fertilized with pollen of White Frontignan. **Fruit:** dark amber, round, medium, skin thin, pulp firm and rather tart, flavor excellent, like Frontignac, and free from foxiness, rather late. **Cluster:** large, shouldered very compact. **Vine:** very vigorous, very healthy and productive.

FOUR-TWENTY. **Parentage:** seed of Black Hamburg fertilized with pollen of Black Fox. **Fruit:** black with a blue bloom, oval, very large, skin very thick, pulp rather hard and acid, flavor peculiar, spicy and delicious, no foxiness, rather late. **Cluster:** large, irregularly shouldered, broken and open. **Vine:** very vigorous, hardy and healthy.

TWELVE. **Parentage:** seed of Amber Fox fertilized with pollen of Black Hamburg. **Fruit:** black with blue bloom, round, good size, skin thin, pulp tender and sweet, flavor good, no foxiness, early. **Cluster:** medium, small shoulders, compact. **Vine:** of medium vigor, very hardy and healthy.

ONE-THIRTY-SIX. **Parentage:** seed of Black Hamburg fertilized with pollen of Black Fox. **Fruit:** black, blue bloom, round, large, skin thick, pulp firm, flavor good, no foxiness, quite late. **Cluster:** large, large shoulders, full, excellent form. **Vine:** vigorous, hardy, healthy and enormously productive.

ONE-EIGHTY-FOUR. **Parentage:** seed of the Grizzly Frontignan fertilized with pollen of Pigeon. **Fruit:** black, round, medium, skin thin, no pulp, quite sweet, Frontignan flavor. **Cluster:** long and without shoulders, pretty close. **Vine:** vigorous, productive, hardy and generally healthy.

TWO-SIXTY-SEVEN. **Parentage:** seed of Pigeon fertilized with pollen of Black Hamburg. **Fruit:** black, round, medium, skin thin, pulp tender, brisk and pretty good. **Cluster:** medium, shouldered, well formed, rather open. **Vine:** healthy, vigorous, hardy and productive.

THREE-HUNDRED-NINE. **Parentage:** seed of Amber Fox fertilized with pollen of White Chasselas. **Fruit:** dark amber, slightly oval, medium, skin thin, pulp tender, excellent flavor, no foxiness, early. **Cluster:** good size, small shoulders, open. **Vine:** vigorous, hardy, very healthy and productive.

THREE-FORTY-THREE. **Parentage:** seed of Amber Fox fertilized with pollen of White Frontignan. **Fruit:** black, round, large, skin thin, pulp tender, flavor good, rather late. **Cluster:** very large, shouldered, compact but not crowded. **Vine:** very vigorous, hardy and productive, generally healthy. The only black grape obtained from many crosses of the Frontignan and Fox.

THREE-SIXTY-SIX. **Parentage:** seed of small Amber Fox fertilized with pollen of White Frontignan. **Fruit:** purple, heavy bloom, round, medium, skin thin. pulp tender, flavor strong of the Frontignan. **Cluster:** medium, small shoulders, compact. **Vine:** very vigorous, hardy, healthy and productive. Young foliage very downy.

THREE-SIXTY-NINE. **Parentage:** seed of small Amber Fox fertilized with pollen of White Frontignan. **Fruit:** red, round, rather small, skin thin, pulp tender, sweet, excellent Frontignan flavor and very early. **Cluster:** medium, not shouldered nor crowded, regular in form. **Vine:** not very vigorous, hardy, very healthy, and moderately productive.

THREE-SEVENTY-ONE. **Parentage:** seed of small Amber Fox fertilized with pollen of White Frontignan. **Fruit:** dark red, round, small, skin thin, pulp firm, with a strong Frontignac flavor, early. **Cluster:** medium, not shouldered, very compact. **Vine:** vigorous, hardy, very healthy and productive.

FOUR-EIGHTEEN. **Parentage:** seed of Black Hamburg fertilized with pollen of Black Fox. **Fruit:** amber, slightly oval, large, skin rather thick, light bloom, pulp tender, sweet and good, with foreign flavor. **Cluster:** large, shouldered, very regular in form, compact. **Vine:** very healthy, very hardy, vigorous and productive.

ONE-TWENTY-TWO. **Parentage:** seed of early Black Fox fertilized with pollen of Black Hamburg. **Fruit:** black with a bloom, round, large, skin thin, pulp tender, red and quite good, very early, **Cluster:** medium, small shoulders, rather open. **Vine:** of moderate vigor, hardy, moderately productive.

THREE-SEVENTEEN. **Parentage:** seed of large Amber Fox fertilized with pollen of White Chasselas. **Fruit:** amber, oval, large, skin thin, pulp tender. **Cluster:** large, shouldered, not very compact, of regular form. **Vine:** vigorous, hardy, healthy and very productive.

THREE-THIRTY-FOUR. **Parentage:** seed of large Amber Fox fertilized with pollen of White Frontignan. **Fruit:** nearly white, round, large, skin thin, pulp tender, sweet and good flavor. **Cluster:** medium, small shoulders, open. **Vine:** vigorous, hardy, and productive, foliage downy.

THREE-SIXTY-SEVEN. **Parentage:** seed of small Amber Fox fertilized with pollen of White Frontignan. **Fruit:** nearly white, round, large, skin thin, pulp tender, high Frontignan flavor. **Cluster:** long, without shoulders, rather open. **Vine:** vigorous, hardy, productive, a little subject to mildew.

THREE-SEVENTY-THREE. **Parentage:** seed of small Amber Fox fertilized with pollen of White Frontignan **Fruit:** white or light amber, round, large, skin thin, pulp tender, excellent Frontignan flavor. **Cluster:** large, large shoulders, not very close. **Vine:** of medium vigor, very hardy, healthy and productive.

ONE-SIXTY-NINE. **Parentage:** seed of Pigeon fertilized with pollen of Grizzly Frontignan. **Fruit:** black, round, small, skin thin, no pulp, rather tart, early, should hang late. **Cluster:** medium, shouldered, not very compact. **Vine:** very hardy and healthy. moderately productive but vigorous.

ONE-EIGHTY-EIGHT. **Parentage:** seed of Grizzly Frontignan fertilized with pollen of Pigeon. **Fruit:** black, round, small, skin thin, blue bloom, no pulp, rather tart, juice red. **Cluster:** large, very long, small shoulders, very compact. **Vine:** very vigorous, hardy, healthy and very productive.

TWO-TWENTY-NINE. **Parentage:** seed of Black Hamburg fertilized with pollen of Pigeon. **Fruit:** black, round, large, skin thin, no pulp, juice red and rather tart, should hang late. **Cluster:** very large, broad and long, compact. **Vine:** very vigorous, healthy and hardy, very productive.

THREE-TWENTY-FOUR. **Parentage:** seed of Amber Fox fertilized with pollen of White Frontignan. **Fruit:** white, round, large, skin thin, pulp very tender, flavor good and free from foxiness. **Cluster:** very large, shouldered, full but not crowded. **Vine:** vigorous, hardy, healthy and productive.

THREE-FORTY. **Parentage:** seed of large Amber Fox fertilized with pollen of White Frontignan. **Fruit:** nearly white, round, large, skin thin, pulp tender, excellent flavor, no foxiness. **Cluster:** very long, without shoulders, close but not crowded. **Vine:** vigorous, hardy and productive, sometimes and to a small degree affected with mildew.

NINETEEN. **Parentage:** seed of small Amber Fox fertilized with pollen of Black Hamburg. **Fruit:** black, little bloom, round, small, skin thin, pulp tender and slightly acid, quite early. **Cluster:** medium, shouldered, very compact. **Vine:** vigorous, hardy, very productive and healthy.

SIXTY-FOUR. **Parentage:** seed of small Amber Fox fertilized with pollen of Black Hamburg. **Fruit:** red, round, small, skin thin, pulp tender, very good flavor. **Cluster:** small, shouldered, open. **Vine:** very vigorous and healthy, hardy, not very productive.

THREE HUNDRED. **Parentage:** seed of Amber Fox fertilized with pollen of White Chasselas. **Fruit:** white or very light amber-round, large, skin thin, flavor good, early. **Cluster:** large, shouldered, compact. **Vine:** vigorous, hardy, very healthy and productive.

THREE-HUNDRED-SIX. **Parentage:** seed of large Amber Fox fertilized with pollen of White Chasselas. **Fruit:** light amber, round, small, skin thin, pulp tender, very good and very early. **Cluster:** small, slight shoulders, compact. **Vine:** medium vigor, small firm wood, hardy, moderately productive.

THREE-FORTY-TWO. **Parentage:** seed of large Amber Fox fertilized with pollen of White Frontignan. **Fruit:** nearly white, round, large, skin thin, pulp tender, sweet and good, flavor good. **Cluster:** medium, shouldered, compact. **Vine:** vigorous, hardy, healthy and very productive.

THIRTY-FIVE. **Parentage:** seed of small Amber Fox fertilized with pollen of Black Hamburg. **Fruit:** light amber, round, medium, skin thin, pulp tender and sweet. **Cluster:** medium, small shoulders, open. **Vine:** very vigorous, healthy and productive, wood rather soft and tender.

FIFTY-EIGHT. **Parentage:** seed of small Amber Fox fertilized, with pollen of Black Hamburg. **Fruit:** red, small, round, skin thin, little pulp, sweet and very early. **Cluster:** small, sets irregularly, open. **Vine:** vigorous, very healthy and hardy.

SEVENTY-FIVE. **Parentage:** seed of Black Fox fertilized with pollen of Black Hamburg. **Fruit:** black, blue bloom, round, large, skin thick, pulp tender, sprightly, flavor good, not foxy, early. **Cluster:** large, large shoulders, full, holds the fruit late. **Vine:** very vigorous, very hardy, healthy and productive.

NINETY-FIVE. **Parentage:** seed of large Amber Fox fertilized with pollen of Black Hamburg. **Fruit:** amber, round, large, pulp very tender and tart, flavor very good, not foxy, early. **Cluster:** medium, without shoulders, open, irregular. **Vine:** medium vigor, very hardy and healthy, moderately productive.

ONE-TWENTY-EIGHT. **Parentage:** seed of very early Black Fox fertilized with pollen of Black Hamburg. **Fruit:** light amber, medium, round, skin thin, pulp tender, sweet, of excellent flavor, early. **Cluster:** medium, small shoulders. **Vine:** rather feeble grower, very hardy and healthy, shy bearer.

LETTER

OF THE

COMMISSIONER OF AGRICULTURE

TO THE

HON. JNO. W. JOHNSTON,

CHAIRMAN OF THE COMMITTEE ON AGRICULTURE, U. S. SENATE,

ON

SORGHUM SUGAR.

WASHINGTON:
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DEPARTMENT OF AGRICULTURE,
Washington, D. C., April 8, 1880.

Hon. JNO. W. JOHNSTON,
United States Senate:

SIR: I have the honor to acknowledge the receipt of your communication of the 24th ultimo, inclosing Senate bill No. 1514, and also the resolution introduced by Hon. A. S. Paddock, and adopted in committee, requesting the Commissioner of Agriculture "to furnish a written report giving all the information in his power in regard to the manufacture of sugar from sorghum and Chinese sugar-cane, its cost, the character and cost of the machinery necessary, &c., together with statistics of the consumption and production of sugar in the United States and all matters bearing on the subject."

Replying seriatim to these inquiries, I submit the following, in some respects hastily-prepared, statement, which, while it is not as complete an answer to the resolution as I would desire to make, yet is as full as can be prepared in the limited time at my command.

The introduction and widespread distribution by the department of the variety of sorghum called Minnesota Early Amber (the juice of which is supposed to granulate more readily than that of many other varieties) has given a great impetus within the past two years to the cultivation of the sorghum cane and to the manufacture of sugar therefrom. It is earlier than any other known variety, ripening its seed in from ninety to one hundred days, and (as appears from reports made to the department, and in which are given the results obtained in almost every State in the Union) yields bountifully an excellent quality of sirup, besides, in many cases, good sugar, although all the operations reported, except the operation of F. A. Waidner & Co. at Crystal Lake, Ill., were carried on with open-pan evaporation. It should also be remarked that these reports show that the farmers who have raised this variety of cane during the past year believe it to be better, from the quality of juice obtained, as well as from the quantity per acre, than any other variety previously cultivated. These opinions, however, are the opinions of farmers who have not had the opportunity to make comparative tests, and who compare the results with those obtained from former cultivation and manipulation, from their recollection rather than from note-books in which experiments have been carefully recorded.

We have now in the department some thirty-two varieties of sugar-producing sorghums and millets, all of which are valuable to a greater or less degree, according to the varying soil, climate, cultivation, seasons, and process of manufacture. That other valuable varieties of sorghum are to be obtained is altogether probable. The so-called Honduras sorghum is only one of the varieties native to the country of Honduras; and I have information that leads me to believe that there are several varieties growing in Central America and also at the mouth of Rio de la Plata, in South America. It is not impossible that varieties superior to any we now have may, in a few years, be common amongst us. It is of h e highest importance to the country at large that all obtainable varieties of cane should be carefully and scientifically examined; and, if possible, they should be grown in various soils and climates, that we may know which is best adapted to particular localities, which will give the best results for the least expense, and which, in the hands of the least intelligent, can be most easily manipulated.

For the northern part of the United States there is probably no cane so suitable as the Early Amber; and, perhaps, it might be said that no other variety would ripen sufficiently to yield sugar with certainty (although it might give good sirup) above the latitude of Chicago. Below this latitude the Liberian might be planted as auxiliary to the Early Amber, while in the latitude of Saint Louis and to the south of it, Honduras sorghum should be added to the other two varieties; thus extending the season for working the cane into sugar many weeks beyond the period that could be utilized in this way if but one kind of cane were planted—the Early Amber ripening in about ninety to one hundred days, the Chinese two weeks later, and the Honduras some five weeks after the Chinese, all being planted at the same time.

Illustrations of the seed-bearing tops of these different varities have been prepared for the forthcoming annual report of this department and are included in this reply, in inclosure marked A.

At a meeting of the Northwestern Cane Growers' Association held in Minnesota last season, the subject of planting, cultivating, and harvesting Early Amber cane and of its manufacture into sugar was so thoroughly discussed that a *résumé* of the proceedings of that convention will probably give as much practical information on the question as can be condensed into the same space. The convention decided that as to the kind of seed to be planted in Minnesota there was no room for debate, the Early Amber being the only sort that would ripen in that high latitude; but the discussion of the characteristics of soil best adapted to the cane showed some difference of opinion as to the availability of new land. But for fuller information touching these matters I would respectfully refer you to inclosure marked B.

The experimental work done at the department during the past two years in examining different sorghums has shown that old ideas in relation to the habit of the different varieties of this plant need to be corrected in many respects. The chemist of the department has demonstrated that there is practically but little if any difference in the juice of different varieties; that all varieties produce sugar that can be easily granulated, if the cane be taken at the proper period of growth; and that the only important question yet to be determined is as to the variety that will yield the largest amount in a given soil and climate. The Early Amber, the Liberian, the Chinese, and the Honduras, planted the past year within the corporate limits of this city, all yielded excellent results, as will be seen from the following report of the chemist of the department, prepared for our annual report for 1879 not yet published:

Hon. W. G. Le Duc,
Commissioner of Agriculture:

Sir: I have the honor to submit the following results of our recent experiments in the manufacture of sugar from the stalks of corn, sorghum, and pearl millet, made at the Agricultural Department during the year 1879.

During the past season there have been made several series of investigations for the purpose of determining the development of sugar in the juices of several varieties of sorghum and of pearl millet, and the results are such as to warrant their being given to the people at the earliest opportunity.

These investigations appear to demonstrate that there exists little difference between the various kinds of sorghum as sugar-producing plants; and, what is quite a surprising result, each of them is, at a certain period of its development, nearly if not quite as rich in sugar as the very best of sugar-cane. It is a matter, also, of extreme practical importance that this maximum content of sugar is maintained for a long period, and affords sufficient time to work up a large crop. Another result of these investigations has been to satisfactorily explain the cause of repeated failure in the production of sugar during the past quarter of a century, and to give the assurance that in the future such failure need not attend this industry. For the purpose of making clear the above points, the results obtained in the laboratory and in out-of-door experiments are appended.

The varieties of sorghum grown and subjected to continuous investigation during the season were Early Amber, White Liberian, Chinese, and Honduras, and Pearl Millet. Besides the above there were made very many examinations of other specimens of sorghums and corn-stalks; all the results of which only confirmed the general principle above stated, viz, the practical equality and great value of every variety of this plant.

In the following table are given the results of the analysis of each of the plants in the successive stages of development. It will be observed that the amount of glucose (or uncrystallizable sugar) diminishes, and the amount of sucrose (or true cane-sugar) increases. It will also be observed that the plants differ widely in the date when the sucrose is at its maximum, but are alike in this, that this maximum is attained at about the same degree of development of the plant, viz, at full maturity, as indicated by the hard, dry seed, and the appearance of off-shoots from the upper joints of the stalk. It is also to be observed that the heavy frost of October 24, which was sufficient to produce one-half inch of ice, did not cause any marked diminution of sugar.

For purpose of comparison, analyses are also appended of three varieties of sugar-cane received from Louisiana, which arrived in excellent condition, and doubtless fairly represented the average character of this famous sugar-plant.

It will be understood that the results of these tables are to be taken as a whole, since it was practically impossible to secure in each case specimen stalks for examination in the laboratory, the development of which in every case corresponded to the date when the plant was cut, and, therefore, it doubtless happened that plants taken from the same row upon September 15, for example, were in reality no further developed than those selected a week earlier, but taken as a whole the several series of analyses are convincing as showing the rate and progress of development of saccharine matter in the plant.

By reference to the tables it will be seen that the analyses made of the several sorghums under date of October 29, were, after they had been subjected to a very hard frost, sufficient to have formed ice one-half inch in thickness, and this cold weather continued for four days before this examination was made. As will be seen, there appears no diminution of sucrose in either of the stalks examined and no increase of glucose as the result of this freezing and continued exposure to a low temperature. The examination of November 8 was made after a few days of warm weather had followed this cold spell, and the influence of this subsequent thaw is noticeable in the diminution of sucrose and the increase of glucose in each specimen examined.

From this it would appear that the effect of cold, even protracted, is not injurious to the quality of the canes, but that they should be speedily worked up after freezing and before they have again thawed out. This is a matter of such practical importance that some experiments should be made to learn whether the sirup prepared from the juice of frozen cane differs from that prepared from cane not frozen but in other respects of like quality.

The Early Amber, Chinese, Liberian, and Honduras sorghums and the Pearl Millet examined, mentioned as having been grown upon the department grounds, were all planted the same day, May 15, 1879.

The relative weights of the different kinds of sorghum experimented upon are as follows:

	Pounds.
Early Amber, average of 40 stalks	1.73
White Liberian, average of 38 stalks	1.80
Chinese, average of 25 stalks	2.00
Honduras, average of 16 stalks	3.64

Since these were all grown side by side and upon land presumably of equal fertility, it will afford the data for calculating the relative amount of each variety to be grown per acre.

Early Amber.

Date.	Development.	Number of stalks used for analysis.	Height of entire stalk, in feet.	Height of top, in feet.	Height of butt, in feet.	Diameter of butt, in feet.	Weight of entire stalk, in pounds.	Weight of stripped stalk, in pounds.	Weight of top.	Weight of butt.	Per cent. of water in top.	Per cent. of water in butt.	Average per cent. of water in cane.	Weight of juice in top.	Weight of juice in butt.	Total weight of juice.	Per cent. of juice in entire cane.	Specific gravity of juice from tops.
July 18	Flower stalks just out; compact	2	6	4.3	2.4		3.32	2.64			82.39	83.00	82.70	.58	.57	1.15	34.6	1.046
July 26	Flower stalks begun to spread	2	8.2	5.7	2.5		2.74				75.35	51.03	63.19	.49	.59	1.08	39.6	1.064
Aug. 7	Flower stalks spreading; seed milky	2	5.1	2.8	2.3	.075	2.80	2.10			74.94	78.63	76.79	.46	.59	1.05	37.5	1.071
Aug. 11	Seed browning; harder	2	5.4	2.9	2.5	.075	2.80	2.12			71.06	76.48	73.77	.47	.59	1.06	37.9	1.078
Aug. 13	Seed harder; stalk suckering	2	5.2	2.9	2.3	.063	3.14	2.12			70.70	69.62	70.16	.45	.55	1.00	31.9	1.082
Aug. 16	do	2	6.4			.075	3.64	2.30			89.96	72.17	80.07	.90	.69	1.59	32.7	1.081
Aug. 20	Seed nearly dry but crushable	2	5.8	3.3	2.5	.068	3.02	2.14						.46	.57	1.03	33.8	1.081
Aug. 22	Seed hard but splitable	2	5.6	3.1	2.5	.075	3.52	2.48						.50	.60	1.10	31.3	1.077
Aug. 26	do	2	5.2	3.1	2.1	.083	4.52	2.84				71.97		.65	.76	1.41	26.9	1.081
Aug. 30	Core of cane turning red	2	5.3			.075	2.52	2.18			67.38	74.17	70.78					1.085
Sept. 8	Ripe; seed dry and mostly gone	2	5.1	2.9	2.2	.070	3.63	2.02			67.07	70.89	68.98	.388	.567	.955	26.2	1.087
Sept. 12	Ripe; seed carried away entirely	2	5.5	3.3	2.2	.06	3.56	1.79	.89	.90	68.47	76.48	72.47	.344	.379	.723	20.3	1.080
Sept. 12	Ripe and dry; carried away by birds	2	5.1	3.2	1.9	.08	3.77	2.02	1.01	1.01	71.61	71.45	71.53	.425	.493	.918	24.3	1.081
Sept. 16	Ripe and dry	2	5.5	3.4	2.1	.08	4.47	1.60	.90	.70	71.60	74.80	73.20	.487	.540	1.027	22.9	1.081
Sept. 22	do	5	5.2			.075	8.80	3.80					76.75			1.775	20.0	
Oct. 3	do	2	5.5	3.4	2.1	.09	4.11	2.04	1.03	1.01	67.75	69.17	68.46	.467	.419	.886	21.5	1.076
Oct. 13	do	2	5.9	3.8	2.1	.07	3.77	1.75	.87	.88	68.47	70.94	69.70	.434	.406	.840	22.2	1.082
Oct. 20	do	2	5.7	3.4	2.3	.07	3.75	1.76	.82	.94	68.34	65.15	66.74	.337	.434	.771	21.2	1.085
Oct. 29	Leaves killed by frost	2	5.1	3.1	2.0	.09	3.03	1.80	.87	.93	68.31	70.45	69.38	.469	.540	1.009	33.3	1.092
Nov. 8	Quite dead	2	5.9	3.7	2.2	.06	2.54	1.76	.83	.93	69.98	71.83	70.90	.318	.494	.812	31.9	1.084
	Foreign.																	
Sept. 11	Brown husks full of milk (D. Smith)	2	6			.082	1.75	1.32					72.36			.513	29.2	
Sept. 13	Just browning (Hutchinson)	2	6	3.7	2.3	.062	2.24	2.01	1.02	.99	78.95	84.82	81.88	.556	.538	1.094	48.8	1.039
Sept. 17	Between milk and dough (D. Smith)	2	6.2	3.8	2.4	.062	1.72	1.27	.67	.60	73.79	72.93	73.36	.295	.317	.612	35.6	1.076
Sept. 13	In dough (Hutchinson)	2	6	3.6	2.4	.062	2.10	1.50	.74	.76	75.83	68.27	72.05	.373	.377	.750	35.6	1.073

Early Amber—Continued.

Date.	Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent. of solids in juice from tops.	Per cent. of solids in juice from butts.	Per cent. of glucose in juice from tops.	Per cent. of glucose in juice from butts.	Per cent. of sucrose in juice from tops.	Per cent. of sucrose in juice from butts.	Average per cent. of glucose.	Average per cent. of sucrose.	Solids (not sugar) in juice from tops.	Solids (not sugar) in juice from butts.	Average solids, not sugar.	Per cent. of sucrose in top by polarization.	Per cent. of sucrose in butt by polarization.	Average per cent. of sucrose by polarization.	Number of analysis.
July 18	Flower stalks just out; compact	1.048	1.047	10.28	10.81	4.7	2.9	4.2	4.7	3.77	4.43	1.43	3.27	2.35				1, 2, 5, 6
July 26	Flower stalks begun to spread	1.064	1.064	14.13	13.07	3.9	2.4	7.8	8.0	3.14	7.85	2.44	2.71	2.53				13, 14
Aug. 7	Flower stalks spreading; seed milky	1.070	1.070	15.85	13.57	3.4	2.6	11.1	11.2	2.97	11.15	1.42	1.77	1.56				17, 18
Aug. 11	Seed browning; harder	1.080	1.079	17.62	17.50	3.0	1.7	13.6	14.0	2.36	13.78	1.06	1.80	1.43				25, 26
Aug. 13	Seed harder; stalk puckering	1.082	1.082	17.52	16.63	1.9	1.6	14.2	14.3	1.74	14.25	1.49	.75	1.12				29, 30
Aug. 16	......do	1.080	1.080	17.62	16.80	1.6	1.5	15.1	14.3	1.54	14.67	.91	1.09	1.00				37, 38
Aug. 20	Seed nearly dry but crushable	1.081	1.081	18.13	18.13	1.9	1.3	14.2	14.0	1.60	14.13	2.05		3.25				41, 42
Aug. 22	Seed hard but splitable	1.074	1.075			1.5	1.5	15.0	14.6	1.48	14.78							49, 50
Aug. 26	......do	1.078	1.079		16.12	1.3	1.3	14.6	14.3	1.31	14.45		.52					57, 58
Aug. 30	Core of cane turning red	1.074	1.079	19.89	17.23	1.2	1.5	14.8	14.7	1.33	11.72	3.92	1.02	2.47				65, 66
Sept. 8	Ripe; seed dry and mostly gone	1.075	1.081	20.50	17.35	.6	.8	9.4	7.5	.7	8.45	10.50	9.05	9.77				92, 93
Sept. 12	Ripe; seed carried away entirely	1.070	1.075	18.47	16.79	.6	.6	14.8	14.7	.6	14.75	3.07	1.49	2.28				90, 91
Sept. 12	Ripe and dry; carried away by birds	1.079	1.080	18.91	18.36	.7	.7	14.5	14.3	.7	14.1	3.71	3.36	3.53				109, 110
Sept. 16	Ripe and dry	1.079	1.080	18.82	18.70	.5	.8	16.1	15.8	.65	15.95	2.22	2.10	2.16				136, 137
Sept. 22	......do		1.079	17.67		.73	.78	14.9	14.7	.7	14.8	2.07		2.27				175, 176
Oct. 3	......do	1.070	1.073	18.63	17.27	.9	1.3	14.7	14.1	1.1	14.4	3.03	1.87	2.45	13.8			206, 207
Oct. 13	......do	1.080	1.081		18.93	.7	.7	15.9	15.7	.7	15.8		2.49		15.1	15.1	15.1	227, 228
Oct. 20	......do	1.083	1.084	20.89	20.75	1.0	.9	16.0	15.5	.95	15.75	3.89	4.35	4.12	15.1	15.2	15.15	251, 252
Oct. 29	Leaves killed by frost	1.081	1.088	21.69	20.76	.9	1.4	17.7	16.3	1.1	17.0	3.09	3.06	3.08				262, 263
Nov. 8	Quite dead	1.073	1.078	19.87	17.57	4.1	4.5	11.9	10.0	4.3	10.9	3.87	3.07	3.47				
	Foreign.																	
Sept. 11	Brown husks full of milk (D. Smith)		1.078	19.36		3.2				3.2	12.1			4.06				83
Sept. 13	Just browning (Hutchinson)	1.031	1.035	9.20	8.40	3.7	3.4	4.6	2.4	3.5	3.5	.90	2.60	1.70				100, 101
Sept. 17	Between hull and dough (D. Smith)	1.070	1.073	18.54	17.30	2.9	3.8	12.2	12.3	3.35	12.25	3.44	1.20	2.32				111, 112
Sept. 13	In dough (Hutchinson)	1.071	1.072	18.37	17.76	2.1	3.6	12.3	8.8	2.85	10.55	3.97	5.36	4.66				98, 99

Chinese.

Date.	Development.	Number of stalks used for anal.	Length of topped stalk, in feet.	Length of top, in feet.	Length of butts.	Diameter of butt, in feet.	Weight of stalk, in pounds.	Weight of stalk stripped, in pounds.	Weight of top.	Weight of butt.	Per cent. of water in top.	Per cent. of water in butt.	Average per cent. of water in cane.	Weight of juice from tops.	Weight of juice from butts.	Total weight, juice, in pounds.	Per cent. of juice on entire cane.	Specific gravity of juice from tops.
Aug. 6	Flower stalk just out, compact	2	4. 8	2. 7	2. 1	. 063	2. 72	1. 82	......	......	83. 03	......	......	. 430	. 440	. 870	......	1. 033
Aug. 6	Flower spreading a little	2	8. 1	5. 8	2. 3	. 083	4. 10	2. 82	......	......	83. 55	84. 42	83. 99	. 630	. 710	1. 340	32. 7	1. 044
Aug. 12	Seeds beginning to brown	2	5. 7	3. 3	2. 4	. 083	3. 60	2. 52	......	......	79. 17	84. 15	81. 66	. 540	. 670	1. 210	33. 7	1. 061
Aug. 19	Seeds browner	2	6. 4	4. 4	2. 2	. 075	3. 58	2. 22	......	......	74. 49	83. 05	78. 77	. 450	. 570	1. 020	29. 0	1. 067
Aug. 29	Seeds soft but not milky	2	6. 6	4. 4	2. 2	. 075	3. 28	2. 28	......	......	67. 88	70. 81	69. 35	. 430	. 490	. 920	28. 2	1. 074
Sept. 8	Seeds still green in parts and milky	2	5. 8	3. 5	2. 3	. 093	5. 62	3. 55	......	......	71. 84	76. 46	74. 15	. 769	. 944	1. 713	30. 4	1. 073
Sept. 13	Seeds dropping and hard	1	7. 1	4. 7	2. 4	. 100	2. 86	1. 82	. 91	. 91	70. 01	72. 54	71. 27	. 395	. 410	. 805	28. 1	1. 085
Sept. 20	Seeds nearly gone	2	5. 7	3. 6	2. 1	. 079	4. 17	2. 43	1. 21	1. 22	76. 98	72. 21	74. 09	. 571	. 586	1. 157	27. 7	1. 082
Sept. 27	......do	2	4. 9	2. 9	2. 0	. 082	3. 27	1. 89	. 93	. 96	70. 75	75. 04	72. 89	. 417	. 417	. 834	25. 5	1. 081
Oct. 3	Dry and ripe	2	5. 8	3. 86	1. 9	. 082	4. 10	2. 23	1. 31	. 92	76. 10	66. 61	71. 35	. 516	. 490	1. 006	24. 5	1. 086
Oct. 14	......do	2	6. 0	4. 0	2. 0	. 088	4. 49	2. 29	1. 08	1. 21	66. 55	73. 00	69. 77	. 476	. 670	1. 146	25. 5	1. 081
Oct. 21	Dry and ripe, red juice	2	6. 1	4. 0	2. 1	. 081	4. 43	2. 35	1. 05	1. 30	69. 88	71. 93	70. 90	. 428	. 553	. 981	22. 1	1. 077
Oct. 29	Dry, and leaves killed by frost	2	5. 2	3. 2	2. 0	. 075	3. 65	2. 26	1. 03	1. 23	67. 87	71. 15	69. 51	. 553	. 578	1. 131	31. 0	1. 076
Nov. 8	Quite dead	2	5. 6	3. 6	2. 0	. 088	3. 21	2. 30	1. 05	1. 25	70. 09	74. 36	72. 22	. 511	. 657	1. 168	36. 4	1. 086
	Foreign.																	
Sept. 11	Seed just forming (D. Smith)	2	7. 4	4. 6	2. 8	. 083	2. 84	2. 30	1. 16	1. 14	......	......	75. 07	......	......	. 814	28. 7	......
Sept. 17	Seed just browning (D. Smith)	2	7. 4	5. 3	2. 1	. 062	1. 68	1. 31	. 65	. 65	71. 62	72. 59	72. 10	. 315	. 309	. 624	37. 1	1. 065
Sept. 30	Seed in the milk	3	6. 1	......	......	. 059	2. 52	1. 88	......	......	73. 39	72. 39	72. 89	. 328	. 368	. 696	27. 6	1. 079
Oct. 8	Seed in dough	2	6. 4	3. 6	2. 8	. 065	3. 09	2. 26	1. 06	1. 20	68. 55	70. 63	69. 59	. 457	. 494	. 951	30. 8	1. 082

Chinese.

Date.	Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent. solids in juice from tops.	Per cent. solids in juice from butts.	Per cent. glucose tops.	Per cent. glucose butts.	Per cent. sucrose tops.	Per cent. sucrose butts.	Average per cent. glucose.	Average per cent. sucrose.	Solids not sugar, in juice, from tops.	Solids not sugar, in juice, from butts.	Average per cent. solids not sugar, in juice.	Per cent. sucrose, by polarization, tops.	Per cent. sucrose, by polarization, butts.	Average per cent. sucrose by polarization.	Number of analysis.
Aug. 6	Flower stalk just out, compact	1.041	1.037	6.87	8.83	5.9	5.2	1.0	2.7	5.55	1.85		.92					9–10
Aug. 6	Flower spreading a little	1.048	1.046	9.02	9.84	6.2	6.3	2.7	3.4	6.1	3.05	1.2	.14	.13				11–12
Aug. 12	Seeds beginning to brown	1.057	1.059	12.70	12.09	5.2	4.2	6.3	6.3	4.6	6.3	1.2	.59	.89				21–2
Aug. 19	Seeds browner	1.063	1.065	14.00	12.12	4.6	5.9	7.1	5.8	5.25	6.45	2.3	.42	1.36				33–4
Aug. 29	Seeds soft but not milky	1.072	1.073	15.73	15.14	3.6	3.2	12.9	11.4	3.4	12.15		.54					53–4
Sept. 8	Seeds still green in parts and milky	1.071	1.072	17.79	18.01	1.7	2.8	10.5	7.6									67–8
Sept. 13	Seeds dropping and hard	1.081	1.083	20.21	22.33	.9	2.0	15.2	12.6	1.45	13.9	4.11	5.73	4.92				96–7
Sept. 20	Seeds nearly gone	1.081	1.081	20.21	17.52	1.4	2.6	14.2	13.3	2.0	13.75		.62					132–3
Sept. 27	do	1.081	1.081	18.43	18.20	1.2	1.7	14.6	14.4	.95	14.50	2.63	2.33	.48		15.2		147–8
Oct. 3	Dry and ripe	1.079	1.082	20.44	23.73	1.6	3.2	11.4	11.9	2.4	11.65	7.44	8.63	8.03	15.3	13.5	14.4	179–80
Oct. 14	do	1.082	1.081	18.61	19.11	1.3	1.9	14.7	15.4	1.6	15.05	2.61	1.81	2.21	14.2	15.2	14.7	213–4
Oct. 21	Dry and ripe, red juice	1.077	1.077	18.37	19.60	1.3	1.5	13.8	15.5	1.4	14.85	3.27	2.60	2.93				232–3
Oct. 29	Dry, and leaves killed by frost	1.077	1.076	17.83	18.51	2.1	1.6	12.5	13.8	1.85	13.15	3.23	2.43	2.83				253–4
Nov. 8	Quite dead	1.082	1.084	19.61	19.39	4.8	2.8	12.3	14.3	3.8	13.3	2.51	2.29	2.40				264–5
	Foreign.																	
Sept. 11	Seed just forming (D. Smith)		1.065	15.28						6.3	6.9			2.08				84–5
Sept. 17	Seed just browning (D. Smith)	1.058	1.061	15.59	14.37	6.9	7.7	6.9	6.6	7.3	6.7	1.79	.17	.98				116–7
Sept. 30	Seed in the milk	1.075	1.077	19.04	17.89	11.0	13.2	8.1	6.0	12.1	7.0				4.9	3.2	4.90	165–6
Oct. 8	Seed in dough	1.078	1.080	15.16	19.05	7.8	10.1	9.3	7.5	8.5	8.8		1.45		7.2	5.2	6.2	191–2

LIBERIAN.

Date.		Development.	Number of stalks used for analysis.	Length of stalk, in feet.	Length of top, in feet.	Length of butt, in feet.	Diameter at butt, in feet.	Weight of stalk, in pounds.	Weight of stalk stripped.	Weight of top, in pounds.	Weight of butt, in pounds.	Per cent. of water in top.	Per cent. of water in butt.	Average per cent. water in cane.	Weight of juice from tops.	Weight of juice from butts.	Total weight of juice, in pounds.	Per cent. of juice in entire cane.	Specific gravity of juice from tops.
July	18	Flower-stalk just out and compact	2	6.1	3.5	2.6		3.28	2.62			83.79	83.31	83.55	.60	.59	1.19	36.4	1.046
	26	Flower-stalk spreading; seed milky	2	8.2	5.7	2.5	.083	2.64	2.52			79.71	78.93	79.32	.49	.60	1.09	38.5	1.043
Aug.	7	Flower-stalk more spreading; seed milky.	2	5.4	2.5	2.9		2.76	2.52			75.75	78.36	77.06	.45	.71	1.16		1.061
	11	Seed browning; harder	2	5.8	3.0	2.8		3.42	2.66			72.79	76.36	74.58	.48	.62	1.10	31.7	1.079
	13	Seed harder	2	5.8	3.6	2.2	.063	3.52	2.58			70.98	75.73	73.36	.66	.70	1.36	39.2	1.081
	16	Juice brown in color	2	8.0	5.7	2.3	.075	3.80	2.40			71.96	72.00	71.98	.59	.62	1.21	31.0	1.087
	20	Seed as before	2	8.2	5.7	2.5	.075	3.98	2.34			69.77	73.31	71.54	.50	.65	1.15	28.9	1.085
	22	Seed almost dry	2	5.5				4.14	2.62				75.91		.59	.62	1.21	29.2	1.083
	26	do	2	5.3	3.1	2.2	.078	4.16	2.44			69.37			.58	.64	1.22	29.5	1.085
	30	Butt turned red at center	2	4.9	2.6	2.3	.075	3.76				70.21	72.47	71.34					1.080
Sept.	8	Ripe; seed dry	1	6.5	3.9	2.6	.072	2.10	1.26			70.30	71.42	70.86	.289	.295	.584	27.8	1.083
	13	Ripe; seed carried off by birds	2	5.5	2.75	2.25	.062	4.18	2.12	1.12	1.00	70.30	85.06	77.68	.453	.437	.890	21.3	1.082
	15	Ripe and dry	2	5.5	2.75	2.25	.062	4.04	2.01	1.02	.99	70.98	71.84	71.41	.494	.399	.893	22.1	1.081
	20	do	2	5.2	3.20	2.0	.088	3.66	2.19	1.13	1.06	75.00	75.56	75.28	.542	.556	1.098	21.1	1.078
	27	Ripe and dry; largely suckered	2	6.07	3.71	2.36	.088	4.59	2.32	1.17	1.15	70.00	72.01	71.00	.445	.529	.974	21.2	1.074
Oct.	3	do	2	5.08	2.95	2.13	.075	3.20	1.81	.92	.89	71.72	76.10	73.91	.423	.426	.849	26.6	1.078
	13	Ripe and dry; juices bright red	2	5.08	3.05	2.03	.072	3.33	1.61	.82	.79	69.22	71.68	70.45	.388	.362	.750	22.5	1.080
	21	Juices bright red	2	5.74	3.38	2.36	.072	3.36	1.84	.97	.97	65.65	80.49	73.07	.346	.406	.752	22.6	1.068
	29	Leaves killed by frost	2	5.08	3.05	2.03	.069	2.49	1.57	.78	.79	67.24	72.08	69.66	.344	.375	.719	28.8	1.082
Nov.	8	Quite dead	2	4.43	2.46	1.97	.079	2.18	1.21	.58	.63	69.89	71.46	70.17	.322	.323	.646	29.6	1.081
		FOREIGN.																	
Sept.	17	Seed just brown; not in milk	1	7.20	4.54	2.66	.083	2.67	2.10	1.01	1.09	74.93	78.41	76.67	.461	.428	.889	33.2	1.055
Oct.	1	Browning, but not much milk	2	6.63	4.17	2.46	.085	2.77	2.26	1.14	1.12	72.64	71.54	72.09	.426	.461	.887	32.0	1.070
	8	Brown and in milk	2	7.54	4.75	2.79	.092	4.01	3.12	1.44	1.68	74.73	75.06	74.89	.662	.792	1.454	36.2	1.074
	24	Brown and hard	2	7.54	4.69	2.85	.075	3.45	2.71	1.34	1.37	61.47	71.02	66.24	.423	.527	.950	27.5	1.088

LIBERIAN—Continued.

Date.		Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent. solids in juice from tops.	Per cent. solids in juice from butts.	Per cent. of glucose in juice from tops.	Per cent. of glucose in juice from butts.	Per cent. of sucrose in juice from tops.	Per cent. of sucrose in juice from butts.	Average per cent. glucose in juice.	Average per cent. sucrose in juice.	Solids not sugar in juice from tops.	Solids not sugar in juice from butts.	Solids not sugar, average.	Per cent. of sucrose by polariscope in juice of tops.	Per cent. of sucrose by polariscope in juice of butts.	Average per cent. polariscope.	Number of analysis.
July	18	Flower-stalk just out and compact	1.048	1.047	9.87	10.73	5.2	3.0	4.6	6.9	4.1	5.7	.09	.83	.46	......	......	......	3, 4
	26	Flower-stalk spreading; seed milky	1.048	1.046	8.97	10.10	4.2	2.9	4.1	5.3	3.5	4.7	.72	1.87	1.30	......	......	......	7, 8
Aug.	7	Flower-stalk more spreading; seed milky.	1.066	1.061	14.76	14.53	3.6	2.8	10.0	11.9	3.2	11.0	1.14	......	......	......	......	......	15, 16
	11	Seed browning; harder	1.077	1.078	17.66	17.14	2.8	1.9	13.4	12.4	2.4	12.9	1.49	2.78	2.14	......	......	......	19, 20
	13	Seed harder	1.081	1.081	17.45	17.65	2.2	1.7	13.4	14.2	2.0	13.8	1.78	1.75	1.77	......	......	......	27, 28
	16	Juice brown in color	1.083	1.085	18.81	18.81	1.2	1.4	13.8	14.7	1.3	14.3	3.84	2.70	3.27	......	......	......	31, 32
	20	Seed as before	1.080	1.083	18.90	17.64	1.6	1.5	15.2	13.7	1.5	14.4	2.12	2.49	2.31	......	......	......	39, 40
	22	Seed almost dry	1.081	1.082	......	......	1.4	1.4	15.3	14.0	1.4	14.7	......	......	......	......	......	......	43, 44
	26	......do	1.077	1.082	17.95	15.60	1.3	1.4	14.1	13.4	1.4	13.7	2.59	.82	1.21	......	......	......	51, 52
	30	Butt turned red at center	1.080	1.080	19.16	......	.8	1.2	12.4	12.1	1.0	12.2	4.00	......	......	......	......	......	59, 60
Sept.	8	Ripe; seed dry	1.081	1.082	20.11	19.35	.7	.8	8.7	10.3	.75	8.35	10.71?	8.25	9.48	......	......	......	69, 70
	13	Ripe; seed carried off by birds	1.081	1.080	19.33	19.40	.5	.6	......	16.4	.55	......	......	2.40	......	......	......	......	94, 95
	15	Ripe and dry	1.080	1.080	18.95	18.40	.6	.7	11.3	13.9	.65	12.6	7.05	3.80	5.42	......	......	......	102, 103
	20	......do	1.073	1.075	17.12	15.97	.6	1.0	14.4	14.1	.8	14.25	2.12	.87	1.49	......	......	......	130, 131
	27	Ripe and dry; largely suckered	1.082	1.078	17.05	18.32	.7	1.2	15.8	14.6	.95	15.2	.55	2.52	1.53	14.1	15.3	14.7	145, 146
Oct.	3	......do	1.072	1.075	19.14	16.84	1.1	1.1	14.6	13.7	1.1	14.15	3.44	2.04	2.74	13.9	13.4	13.65	177, 178
	13	Ripe and dry; juices bright red	1.074	1.077	19.08	17.62	.9	1.0	14.7	13.4	.95	14.05	3.48	3.22	3.35	14.15	......	......	208, 209
	21	Juices bright red	1.068	1.068	16.37	16.31	1.1	1,1	11.1	12.5	1.1	11.8	4.17	2.81	3.49	......	......	......	230, 231
	29	Leaves killed by frost	1.079	1.081	19.48	19.49	1.5	2.7	14.3	13.5	2.1	13.9	3.68	3.29	3.48	......	......	......	255, 256
Nov.	8	Quite dead	1.070	1.077	18.86	15.75	2.9	5.2	12.8	8.4	4.0	10.6	3.16	2.15	2.65	......	......	......	266, 267
		FOREIGN.																	
Sept.	17	Seed just brown; not in milk	1.051	1.053	13.25	12.94	4.9	7.2	7.4	5.2	6.05	6.2	.95	.54	.74	......	......	......	117, 118
Oct.	1	Browning, but not much milk	1.068	1.069	16.77	16.24	8.9	9.9	8.2	7.1	8.55	8.50	......	......	......	......	......	......	167, 168
	8	Brown and in milk	1.065	1.069	13.16?	17.64	4.9	8.3	11.6	......	6.65	......	......	......	......	......	......	......	189, 190
	24	Brown and hard	1.087	1.087	16.77	21.12	2.3	3.9	17.2	16.8	3.1	17.00	......	.42	......	......	......	......	241, 242

Honduras.

Date.	Development.	Number of stalks used for analysis.	Length of topped stalk, in feet.	Length of top, in feet.	Length of butt, in feet.	Diameter at butt, in feet.	Weight of whole stalk, in pounds.	Weight of stalk stripped.	Weight of top, in pounds.	Weight of butt, in pounds.	Per cent. of water in top.	Per cent of water in butt.	Average per cent. of water in stock.	Weight of juice from tops, in pounds.	Weight of juice from butts, in pounds.	Total weight of juice, in pounds.	Per cent. of juice in entire cane.	Specific gravity of juice from tops.	Specific gravity of juice from butts.
Aug. 12	No sign of flower stalk; cane 7 ft. high	2	5.8	......	......	......	6.76	5.02	......	......	....	83.99	....	1.17	1.15	2.32	34.4	1.032	1.037
19	Flower stalk just out	2	7.2	4.3	2.9	.104	7.34	5.48	......	......	83.83	84.15	83.99	1.26	1.42	2.68	36.5	1.037	1.042
29	Flower stalk spreading	2	9.1	......	......	.104	7.48	5.98	......	......	83.09	79.67	81.33	1.18	1.85	3.03	37.7	1.040	1.045
Sept. 10	Stamens just fallen; no milk	1	10.1	6.3	3.8	.093	3.21	2.57	......	......	73.51	81.53	77.52	.564	.677	1.241	38.6	1.047	1.050
10	Beginning to brown	1	9.5	6.1	3.4	.125	3.85	2.88	1.25	1.63	80.51	81.73	81.12	.670	.765	1.435	37.2	1.056	1.051
15	In first milk; browning	1	9.7	7.5	2.2	.114	4.32	3.33	1.58	1.75	75.29	80.29	77.79	.730	.811	1.541	35.6	1.057	1.054
19	In milk; brown	1	9.1	5.8	3.3	.093	2.76	1.98	1.02	.96	75.00	75.78	75.39	.426	.427	.853	30.9	1.057	1.057
25	Full milk	1	9.8	6.6	3.2	.098	3.21	2.53	1.17	1.36	77.03	80.26	78.64	.542	.670	1.212	37.4	1.059	1.057
29	....do	1	9.2	6.0	3.2	.115	4.08	2.90	1.27	1.63	76.10	77.10	76.60	.525	.717	1.242	30.4	1.060	1 061
Oct. 4	Dough	1	9.9	6.4	3.5	.121	4.06	3.00	1.35	1.65	72.52	75.52	74.02	......	.743	....	......	1.070	1.066
14	....do	1	10.8	7.2	3.6	.112	4.08	2.94	1.39	1.55	64.15	69.19	66.62	.520	.642	1.162	28.4	1.074	1.070
20	Harder	1	10.5	7.0	3.5	.112	3.75	2.79	1.29	1.50	68.27	70.52	69.39	.503	.644	1.147	30.6	1.080	1.079
29	Harder; leaves dead	1	10.3	6.7	3.6	.088	3.38	2.92	1.23	1.69	68.85	74.00	71.42	.536	.633	1.169	34.5	1.077	1.074
Nov. 8	Quite dead	1	10.2	6.7	3.5	.105	3.09	2.69	1.25	1.44	69.21	72.27	70.74	.586	.759	1.345	43.5	1.086	1.075
	FOREIGN.—D. SMITH.																		
Sept. 17	Not brown nor milky; heads well out.	1	8.3	5.4	2.9	.114	1.85	1.49	.70	.79	67.22	76.55	71.88	.276	.373	.649	35.0	1.047	1.044
Oct. 1	Young; flower-tops spreading	2	10.8	8.2	2.6	.082	2.58	2.07	1.02	1.05	64.46	68.96	66.71	.284	.392	.676	26.2	1.066	1.058
8	Browning	2	9.0	6.1	2.9	.125	5.81	4.48	2.03	2.45	57.39	76.72	67.05	.860	1.036	1.896	32.6	1.075	1.062
24	Tall stalk; seed first milk	1	7.7	4.6	3.1	.115	3.08	2.61	1.30	1.31	75.77	74.35	75.06	.624	.754	1.378	44.7	1.075	1.070
24	Shorter and more stalky and riper	2	6.2	3.9	2.3	.092	2.83	1.85	.87	.98	63.04	62.35	62.69	.247	.351	.598	21.1	1.065	1.069
	ARSENAL.																		
Sept. 30	Seeds not filled out	1	8.2	5.0	3.2	.092	2.19	1.81	.85	.96	79.40	78.10	78.75	.445	.529	.974	44.4	1.050	1.052
Oct. 15	Seeds greenish brown	1	9.7	5.9	3.8	.102	2.15	1.79	.77	1.02	76.81	....	....	.373	.531	.904	42.0	1.054	1.054

Honduras—Continued.

Date.	Development.	Average specific gravity of juice.	Per cent. solids in juice from tops.	Per cent. solids in juice from butts.	Average per cent. solids in juice.	Per cent. glucose in juice of tops.	Per cent. glucose in juice of butts.	Per cent. sucrose in juice of tops.	Per cent. sucrose in juice of butts.	Average per cent. glucose in juice from cane.	Average per cent. sucrose in juice from cane.	Solids not sugar in juice from tops.	Solids not sugar in juice from butts.	Average per cent. solids not sugar in juice.	Per cent. sucrose by polariscope, tops.	Per cent. sucrose by polariscope in juice of butts.	Average per cent. sucrose by polariscope in juice.	Number of analysis.
Aug. 12	No sign of flower stalk; cane 7 feet high	1.035	6.04	6.97	6.50	4.10	6.2	1.7	.8	5.13	1.2	.24						
19	Flower stalk just out	1.040	7.63	8.46	8.04	5.4	5.0	2.2	3.4	5.20	3.8	.03						
29	Flower stalk spreading	1.043	8.27	9.44	8.80	4.9	5.1	4.0	4.4	5.00	4.2							
Sept. 10	Stamens just fallen; no milk	1.058	Burned.			3.4	4.0	6.2	5.7	3.7	5.9							75–76
10	Beginning to brown	1.053	12.21	11.32	11.76	3.5	4.1	7.9	6.7	3.8	7.3							77–78
15	In first milk; browning	1.055	13.66	12.56	13.11	3.7	4.0	8.9	8.0	3.8	8.4	1.06	.56	.81				104–5
19	In milk; brown	1.057	13.82	14.60	14.21	2.8	3.1	8.5	8.7	2.9	8.6	2.52	2.80	2.66				127–8
25	Full milk	1.058	13.31	13.23	13.27	2.9	3.8	9.4	8.2	3.3	8.8	1.01	1.23	1.12	9.55	8.7	9.1	143–4
29	....do	1.060	13.92	14.20	14.06	2.4	3.3	10.6	10.4	2.8	10.5	.92	.50	.71	10.0	10.1	10.0	153–4
Oct. 4	Dough	1.068	17.09	16.61	16.85	2.2	3.5	13.0	11.6	2.8	12.3	1.89	1.51	1.70	12.2	10.7	11.4	181–2
14	....do	1.072	17.48	17.72	17.60	1.0	1.8	14.6	14.4	1.4	14.5	1.88	1.22	1.55	13.7	14.0	13.8	211–12
20	Harder	1.079	22.78	19.40	21.09	1.2	1.4	14.9	15.4	1.3	15.1	7.68?	2.60	5.10				225–26
29	Harder; leaves dead	1.075	17.67	17.88	17.77	1.1	1.9	15.0	13.5	1.5	14.2	1.57	2.48	2.02				249–50
Nov. 8	Quite dead	1.080	19.54	17.35	18.44	3.9	3.1	13.4	12.7	3.5	13.0	2.24	1.55	1.89				268–69
	FOREIGN.—D. SMITH.																	
Sept. 17	Not brown nor milky; heads well out	1.045	10.77	10.49	10.63	5.6	5.7	3.6	3.6	5.6	3.6	1.52	1.19	1.35				119–20
Oct. 1	Young; flower-tops spreading	1.062	11.96	13.25	12.60	10.9	11.4	3.4	3.7	11.1	3.6				1.0	.7	.8	163–4
8	Browning	1.068	12.77	14.68	13.72	6.8	8.1	5.6	5.7	7.4	5.6	.37	.88	.62	4.2	4.2	4.2	187–8
24	Tall stalk; seed first milk	1.072	18.14	17.17	17.65	4.3	6.5	13.0	10.7	5.4	11.8	.84						237–8
24	Shorter and more stalky and riper	1.067	14.34	14.05	14.19	4.6	6.4	7.1	5.8	5.5	6.4	2.64	.85	1.74				239–40
	ARSENAL.																	
Sept. 30	Seeds not filled out	1.051	11.73	13.01	12.37	8.0	7.1	3.1	5.4	7.5	4.2	1.91			1.1	3.9	2.5	155–6
Oct. 15	Seeds greenish brown	1.054		13.74		7.5	8.8	4.5	4.1	8.1	4.3		.84					217–8

Miscellaneous sorghums.

Date.	Variety.	Development.	Number of stalks.	Length of topped stalk, in feet.	Length of top, in feet.	Length of butt, in feet.	Diameter at butt, in feet.	Weight of stalk, in pounds.	Weight of stalk stripped, in pounds.	Weight of top, in pounds.	Weight of butt, in pounds.	Per cent. of water in top.	Per cent. of water in butt.	Average per cent. of water in cane.	Weight of juice from tops.	Weight of juice from butts.	Total weight of juice.	Per cent. of juice in entire cane.	Specific gravity of juice tops.
Sept. 9	Gunnison	Green suckers	2	5.7	3.3	2.4	.073	3.74	1.91	......	......	69.42	75.69	72.55	.461	.472	.933	24.9	1.079
Sept. 9	....do..........	Dry suckers	2	5.4	3.1	2.3	.073	4.21	2.21	......	......	71.39	73.63	72.51	.545	.515	1.060	25.1	1.078
Sept. 16	....do..........	Green suckers	2	5.5	3.3	2.2	.083	4.24	2.13	1.03	1.10	81.25	72.48	76.86	.483	.553	1.036	24.4	1.079
Sept. 20	....do..........	Very ripe and dry.....	2	5.7	3.6	2.1	.079	4.13	2.02	1.03	.99	71.33	70.80	71.06	.512	.459	.971	23.5	1.082
Sept. 27	....do..........	......do	2	4.5	2.5	2.0	.075	4.00	1.77	1.87	.90	71.67	70.15	70.91	.401	.467	.862	21.5	1.077
Oct. 10	Mastodon	....	1	14.76	10.82	3.94	0.180	......	6.46	3.23	3.23	77.73	78.67	78.20	1.665	1.720	3.385	......	1.071
Oct. 10	Imphee	....	1	8.8	......	......	.112	2.12	1.98	......	......	......	......	75.24	......	......	1.074	50.6	......
Oct. 10	Black Top......	....	1	10.5	......	......	.092	1.53	1.42	......	......	......	......	71.34	......	......	.746	48.7	......
Oct. 10	Oomseeana	....	1	7.3	......	......	.079	1.37	1.19	......	......	......	......	74.81	......	......	.606	44.2	......

Date.	Variety.	Development.	Specific gravity of juice from butts.	Average specific gravity of juice.	Per cent. solids in juice from tops.	Per cent. solids in juice from butts.	Tops, juice from, per cent. of glucose.	Butts, juice from, per cent. of glucose.	Tops, juice from, per cent. of sucrose.	Butts, juice from, per cent. sucrose.	Average per cent. of glucose in juice of cane.	Average per cent. of sucrose.	Solids, not sugar, in juice from tops.	Solids, not sugar, in juice of butts.	Average of solids, not sugar, in juice.	Sucrose in juice from tops by polarization.	Sucrose in juice from butts by polarization.	Average sucrose in juice by polarization.	Number of analysis.
Sept. 9	Gunnison	Green suckers	1.077	1.078	13.97	15.55	.7	.5	9.3	9.9	.6	9.6	5.55	4.36	4.95	......	......	......	71, 72
Sept. 9	....do..........	Dry suckers	1.076	1.077	17.31	....	.9	1.0	11.6	13.2	.9	12.4	4.81	....	....	.....	......	......	73, 74
Sept. 16	....do..........	Green suckers........	1.082	1.080	18.38	18.67	.6	.6	12.6	13.9	.6	13.2	5.18	4.17	4.62	......	......	......	107, 108
Sept. 20	....do..........	Very ripe and dry....	1.080	1.081	18.77	18.11	.7	.7	15.6	15.1	.7	15.3	2.37	2.64	2.50	......	......	......	134, 135
Sept. 27	....do..........	......do	1.078	1.077	18.24	18.72	.7	.6	15.2	15.9	.6	15.5	2.34	2.08	2.21	......	......	......	149, 150
Oct. 10	Mastodon	....	1.064	1.067	16.92	15.41	1.3	5.8	14.7	8.8	3.5	11.7	.92	.81	.86	......	......	......	....
Oct. 10	Imphee........	....	....	1.068	....	....	......	......	......	......	9.1	6.9	......	....	.28	10.5	6.1	8.3	198, 199
Oct. 10	Black Top......	....	....	1.084	....	....	......	......	......	......	4.5	13.6	......	....	1.74	......	......	4.7	200
Oct. 10	Oomseeana	....	....	1.077	....	....	......	......	......	......	2.3	14.4	......	....	1.70	......	......	11.9	201

Pearl Millet.

Date.	Development.	Number of stocks for analysis.	Length of topped stalks, in feet.	Diameter at butts, in feet.	Weight of whole stalk, in pounds.	Weight of stripped stalk, in pounds.	Per cent. of water in cane.	Weight of juice, in pounds.	Per cent. of juice in stalks.	Specific gravity of juice.	Per cent. of solids in juice.	Per cent. of glucose in juice.	Per cent. of sucrose in juice.	Per cent. of solids, not sugar, in juice.	Polarization.	Number of analysis.
Sept. 10	Stamens still on	2	5.7	.062	1.67	1.12	Burned	.505	30.0	1.035	Burned	1.6	3.7	......	......	79, 80
Sept. 10	Stamens fallen	2	6.7	.062	1.57	1.04	..do ...	.480	30.5	1.034	..do ..	1.6	1.9	......	......	81, 82
Sept. 16	No change in appearance	2	5.3	.073	2.00	1.02	76.31	.373	18.6	1.049	11.17	.8	7.3	3.07	......	106
Sept. 19	......do	2	5.1	.062	1.78	1.09	76.98	.406	22.8	1.049	11.53	1.5	7.0	3.03	......	129
Sept. 25	Dry tops; suckering	3	5.7	.065	2.50	1.49	72.00	.547	21.5	1.054	11.09	1.1	8.7	1.29	......	142
Sept. 29	......do	3	6.6	.065	3.00	2.08	75.53	.783	26.1	1.060	11.21	1.2	9.6	.41	......	152
Oct. 4	Dry tops; suckers well developed	2	5.1	.056	2.09	.98	67.35	.529	25.3	1.061	14.10	1.3	10.1	2.70	......	183
Oct. 14	Leaves dead and yellow	2	6.1	.072	1.85	.97	64.41	.377	20.3	1.068	15.30	2.0	11.3	2.00	......	215
Gct. 20	Frost-withered	2	6.1	.072	1.65	1.06	65.65	.560	33.9	1.058	13.15	3.0	6.7	3.45	......	229
Oct. 29	Quite dead	3	5.6	.059	1.53	.88	72.54	.337	22.0	1.070	16.18	5.4	7.4	3.38	......	248
	Foreign.															
Oct. 24	Withered	2	5.3	.059	1.20	.77	75.77	.302	25.1	1.058	18.14	.5	11.7	5.94	......	243

Miscellaneous.

Date.	Variety.	Development.	Number of stalks.	Length of topped stalk, in feet.	Length of top.	Length of butt.	Diameter at butt.	Weight of stalk, in pounds.	Weight of stalk stripped.	Weight of top.	Weight of butt.	Per cent. of water in top.	Per cent. of water in butt.	Average per cent. of water in cane.	Weight of juice from tops.	Weight of juice from butts.	Total weight of juice.	Per cent. of juice in entire cane.	Specific gravity of juice, tops.
Sept. 17	Egyptian corn		3	4.9	3.0	1.9	.083	2.70	1.85	.90	.95	84.09	85.03	84.51	.329	.493	.822	30.4	1.040
Sept. 11	do		2	4.4	2.9	1.5	.083		1.44	.58	.86	76.44	76.06	76.25	.267	.375	.642		1.062
Sept. 17	Fodder		2	6.5	4.4	2.1	.083	2.42	1.71	.77	.94	78.06	79.27	78.66	.332	.505	.837	34.6	1.035
Sept. 11	Brown doura		2	3.2			.041	.82	.30					70.83			.081	9.8	
Oct. 1	do		3	3.7			.049	1.58	.59					66.54			.095	6.0	
Sept. 11	White doura		2	5.2			.062	1.45	.92					51.56			.207	14.2	
Oct. 1	do		3	4.3			.049	1.58	.59								.097	6.1	
Aug. 23	Corn	Two weeks before plucking ears	3	5.7	3.5	2.2	.068	5.88	3.87			77.34	77.05	77.20	.460	.520	.980	24.8	1.046
Aug. 23	do	At time of plucking ears	3	4.4	2.8	1.6	.088	6.36	3.63			73.04			.430	.670	1.100	26.0	1.051

Date.	Variety.	Development.	Specific gravity of juice, butts.	Average specific gravity.	Per cent. solids in juice from tops.	Per cent. solids in juice from butts.	Tops, glucose.	Butts, glucose.	Tops, sucrose.	Butts, sucrose.	Average glucose in juice from cane.	Average sucrose in juice from cane.	Solids not sugar in juice from tops.	Solids not sugar in butts.	Average solids not sugar, in juice.	Tops by polarization.	Butts by polarization.	Average of polarization.	No. of analysis.
Sept. 17	Egyptian corn		1.035	1.037	9.87	9.22	3.7	4.6	5.5	3.6	4.1	4.5	.67	1.02	.84				
Sept. 11	do		1.064	1.063	14.68	15.07	2.9	2.6	7.6	7.9	2.7	7.7	4.18	4.57	.37				
Sept. 17	Fodder		1.025	1.030	7.93	5.27	4.4	1.8	1.4	1.5	3.1	1.4	2.13	1.97	2.05				
Sept. 11	Brown doura			1.055							.8	3.7			12.51				88
Oct. 1	do			1.056							2.7	3.7			4.88				160
Sept. 11	White doura			1.084							1.9	8.7			7.00				
Oct. 1	do			1.086															
Aug. 23	Corn	Two weeks before plucking ears	1.049	1.048			4.8	4.9	4.9	6.4	4.8	5.6							
Aug. 23	do	At time of plucking	1.047	1.049			3.4	3.4	7.1	6.3	3.4	6.7							

Louisiana sugar canes.

Date.	Variety.	Portion.	Number of stalks.	Total weight, in pounds.	Weight of leaf top.	Weight of bare cane.	Weight of top, stripped.	Total length to end of leaves, in pounds.	Length of bare cane.	Length of leaf top, stripped.	Diameter at butt, in feet.	Diameter at first leaf.	Number of joints in butt.	Number of joints in middle.	Length of first joint.	Length of second joint.	Length of middle joint.	Length of first leaf-joint.	Per cent. of water in cane.	Weight of juice, in pounds.	Per cent. of juice.	Specific gravity of juice.	Per cent. of solids in juice.	Glucose, per cent. of, in juice.	Sucrose, per cent. of, in juice.	Per cent. of solids not sugar, in juice.	Polarization, per cent. sucrose.
Nov. 11	Ribbon-cane plant, 1879	Top	....	......	....	.....	....	......	....	....	.....	.....	....	....	......	....	....	....	85.51	.668	....	1.036	7.36	4.08	1.57	.71	7.08
Nov. 11	....do	Middle.	....	......	....	.....	....	......	....	....	.....	.....	....	....	......	....	....	....	79.19	2.919	....	1.056	13.62	1.98	11.30	.34	11.13
Nov. 11	....do	Butt	2	13.23	2.68	10.55	1.07	13.12	6.72	1.34	.124	.118	8	10	.291	....	....	.262	80.11	3.025	....	1.063	15.28	.71	......	.....	13.97
Nov. 11	....do	Top	....	......	....	.....	....	......	....	....	.....	.....	....	....	......	....	....	....	81.90	.366	....	1.040	8.82	4.29	2.83	1.70	.....
Nov. 11	....do	Middle.	....	......	....	.....	....	......	....	....	.....	.....	....	....	......	....	....	....	78.18	1.464	....	1.057	13.79	1.61	11.30	.88	.....
Nov. 11	....do	Butt	1	6.00	1.19	4.81	.68	12.89	6.99	1.57	.124	.115	9	11	.239	....	.426	.220	76.19	1.486	....	.....	.....	.81	13.64	.....	.....
Nov. 11	....do	Top	....	......	....	.....	....	......	....	....	.....	.....	....	....	......	....	....	....	81.81	.761	....	1.031	10.96	2.94	6.30	1.72	5.97
Nov. 11	Ribbon cane plant, 1878	Middle.	..	......	....	.....	....	......	....	....	.....	.....	....	....	......	....	....	....	91.90	2.381	....	1.067	16.31	.68	15.82	.....	15.79
Nov. 11	....do	Butt	2	10.26	2.63	7.63	1.35	11.81	5.81	1.57	.127 .124	.112	6	9	.164 .295	.246 .361	....	.262 .164	71.63	2.055	....	1.074	17.71	.45	17.17	.09	17.00
Nov. 11	Red cane, 1878	Top	....	......	....	.....	....	......	....	....	.....	.....	....	....	......	....	....	....	81.97	.739	....	1.047	10.32	3.41	2.14	4.77	5.06
Nov. 11	....do	Middle.	....	......	....	.....	....	......	....	....	.....	.....	....	....	......	....	....	....	75.67	2.795	....	1.064	15.59	1.41	13.36	.82	14.07
Nov. 11	....do	Butt	2	11.65	2.30	9.35	1.30	11.48	6.47	1.71	.131 .115	.108	....	....	.203	....	....	.148	78.22	3.113	....	1.066	15.69	1.04	15.26	.39	14.59

For purpose of further comparison the following analyses of sugar-canes and juice of the sugar-cane grown in Madras, India, are given below. The canes were divided into upper, middle, and lower thirds, each third being 2 feet in length, except the lower thirds of the selected canes, which were 3 feet in length.

	Bundle of medium good canes.			Bundle of selected canes.		
	Upper third.	Middle third.	Lower third.	Upper third.	Middle third.	Lower third.
Bagasse	7.630	8.470	8.300	7.580	8.650	8.290
Sucrose	10.630	13.310	13.370	9.490	13.640	13.850
Glucose	2.640	1.510	1.540	2.430	.736	.710
Ash	.307	.259	.233	.545	.363	.349
Water	78.334	75.612	76.122	79.484	75.628	75.945
Undetermined	.459	.839	.455	.471	.983	.856
	100.000	100.000	100.000	100.000	100.000	100.000

ANALYSIS OF EXPRESSED JUICE.

Sucrose	11.510	14.550	14.580	10.270	14.930	15.110
Glucose	2.860	1.650	1.680	2.630	.806	.775
Ash	.333	.283	.255	.590	.398	.381
Undetermined	.497	.917	.485	.510	1.076	.934
Water	84.800	82.600	83.000	86.000	82.790	82.800
	100.000	100.000	100.000	100.000	100.000	100.000

CHEM. CENT. BLATT., *February*, 1880.

For more clearly presenting the facts developed by the examinations of the four kinds of sorghum, the following chart represents graphically the foregoing results:

It will be observed how closely the Early Amber and Liberian correspond in their development, being almost identical, and yet being clearly distinct varieties. It will also be seen that while these two varieties attain a content of sugar in their juices equal to the average content in the juice of sugar-cane by the middle of August, the Chinese does not reach this condition until the last of September, while the Honduras does not reach this point until the middle of October.

It will be seen also that after having attained approximately the maximum content of sugar, this condition is maintained for a long period, affording ample time to work up the crop.

It is doubless true that had the season been longer it would have been found that the Chinese and Honduras having once attained this full development of sugar would also have retained it; but, as is seen by the chart, the heavy frosts and subsequent warm weather which happened about November 24, caused a rapid diminution of sucrose in each variety, and a corresponding increase in glucose.

The converse of what is found true of the sucrose is clearly shown as to the development of the glucose, and it is seen that a minimum quantity once attained is continued a long time, and that this minimum is quite as low as the average amount found present in the sugar-canes.

It is obvious that the results depicted upon the chart are not to be taken as entirely exact, but the general fact represented is without doubt true, and with a still larger number of observations the approach to true curves would be found nearer than here represented.

The line representing the average per cent. of sucrose in sugar-beets is from the results of analysis of thirteen specimens of sugar-beets grown upon the Agricultural College farm, Amherst, Mass., and analyzed by Professor Groessmann (*vide* Mass. Agric. Rept., 1870–'71).

An average of all the examinations made of these four sorghums during these periods when they were suitable for cutting gives the following results:

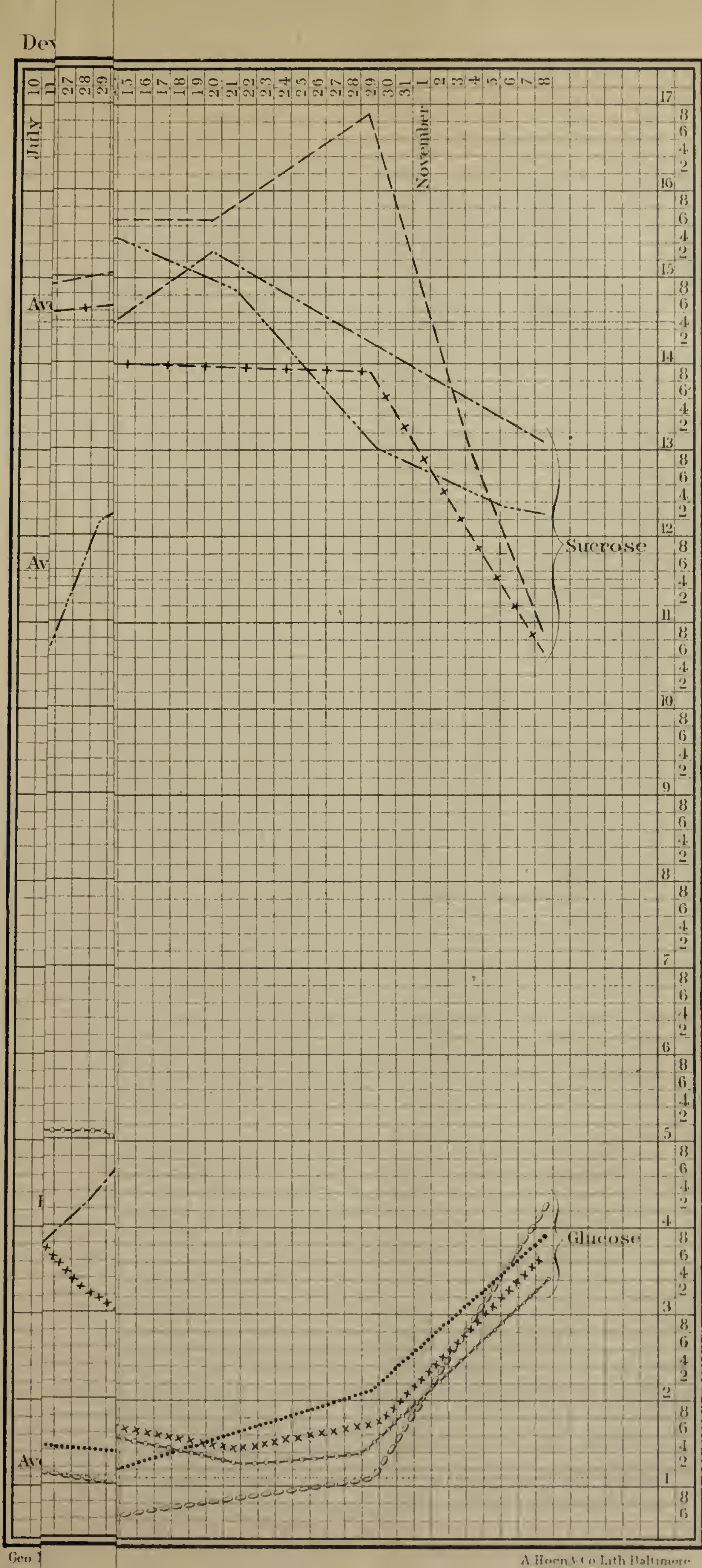
Early Amber, from August 13 to October 29 inclusive, 15 analyses extending over 78 days, 14.6 per cent. sucrose.

Liberian, from August 13 to October 29 inclusive, 13 analyses, extending over 78 days, 13.8 per cent. sucrose.

Chinese, from September 13 to October 29 inclusive, 7 analyses, extending over 46 days, 13.8 per cent. sucrose.

Honduras, from October 14 to October 29 inclusive, 3 analyses, extending over 16 days, 14.6 per cent. sucrose.

Besides the investigations above mentioned, there have been made 35 experiments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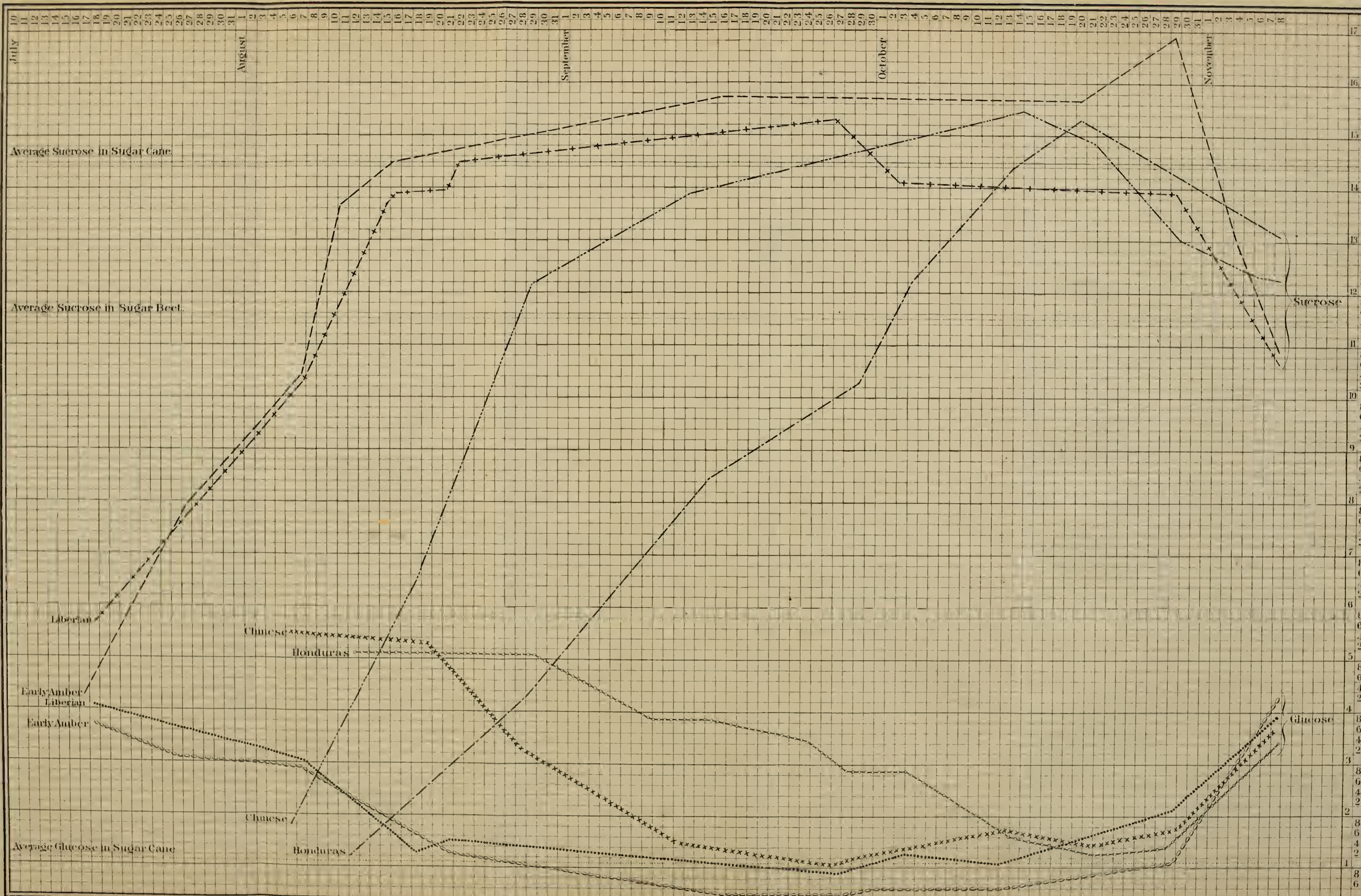
Development of Sucrose and Glucose in Sorghums.



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in making sugar from cornstalks, sorghums, pearl millet, &c., in all of which there have been used over 23 tons of stalks. The result of these experiments has been to fully confirm all the experiments of the previous year, not only, but also to help towards the solution of certain questions of the highest practical importance. In every case it has been found that the quality of the sirup obtained has been precisely such as the previous analysis in the laboratory of the juice used made probable. An average of the nine best sirups obtained showed a percentage of cane-sugar present equal to 92.7 of the amount originally present in the juice, while an average of the nine poorest (*i. e.*, containing the lowest percentage of cane-sugar) showed a percentage of cane-sugar present equal to 90.1 of the amount present in the juice.

This must not be understood to mean that there has been no loss of sugar in the process of manufacture, as such conclusion would be quite erroneous, as will be seen by consulting tables further on in this report.

Below are given the detailed results of 33 experiments in the making of sirups from sorghum, pearl millet, and cornstalks, and analyses of the juices from which these sirups were made. These stalks were obtained from neighboring farmers, and, as will be seen, were never in the condition best suited for working, but the results obtained from them are, however, of great practical value, and are given in detail.

The last column represents the relative loss of sucrose in making sirup, as compared with the glucose present, but gives no indication as to the absolute loss which may have been incurred, and since the economical production of sugar largely depends upon the amount of this loss, this matter is discussed more fully in another place.

	Date of experiment.	Pounds of raw stalks.	Leaves and tops.	Tops.	Stripped stalks.	Topped stalks.	Juice expressed.	Specific gravity of juice.	Per cent. of juice in raw stalks.	Per cent. of juice to stripped stalk.	Per cent. of sucrose in juice.	Per cent. of glucose in juice.	Pounds of sirup obtained.	Per cent. of sirup in raw stalks.	Per cent. of sirup in juice.	Polarization of sirup.	Sucrose in sirup by analysis.	Glucose in sirup by analysis.	Per cent. of total solids in juice.	Per cent. of glucose in juice.	Per cent. of sucrose in juice.	Polarization of juice.	Relative loss of sucrose in making sirup.
Early amber sorghum, topped but not stripped.	Sept. 18	1,603		234		1,369	684	1057	42.67		8.70	4.30	98.5	6.15	14.40	46.4			13.01	4.30	8.70		
	Sept. 24	2,566		395		2,171	1,063	1060	41.43		11.10	3.10	154.0	6.00	14.49	48.0	51.1	29.6		3.10	11.10	11.43	14.9
	Sept. 30	2,436		329		2,107	975	1057	40.02		11.10	3.50	169.1	6.94	17.16	44.3	42.3	20.6	15.41	3.50	11.10	10.50	8.7
	Oct. 1	1,778		258		1,520	660	1061	37.12		11.60	3.70	102.8	5.78	15.67	51.2	56.6	25.2	15.35	3.70	11.60	10.50	6.6
	Oct. 21	891		131		760	382½	1068	42.93		11.91	2.63	58.0	6.51	15.17	58.3	62.9	18.7		2.63	11.91		4.8
Honduras sorghum, topped and stripped.	Oct. 9	556	88		468		229	1072	41.01	48.93	12.30	2.50	41.2	7.41	18.00	51.8	60.9	16.8	16.57	2.50	12.30	11.80	4.7
Honduras sorghum, topped but not stripped.	Oct. 25	281		10		271	113	1077	40.21		10.49	1.14	15.5	5.52	14.40	61.0	70.2	8.6	17.38	1.14	10.49		1.1
Honduras sorghum, topp'd and stripped.	Nov. 1	1,405	231		1,174		666	1058	47.40	56.73	9.24	3.63	97.5	6.94	14.65	37.2	36.4	31.7	13.62	3.63	9.24		18.4
	Nov. 3	1,231	117		1,114		611	1058	49.63	54.85	7.70	5.10	88.5	7.19	14.47	38.1	46.3	32.9	13.49	5.10	7.70		1.7
	Nov. 4	1,431	155		1,276		660	1054	46.12	51.72	5.40	5.40	86.8	6.07	13.16	30.4	39.3	36.1	12.18	5.40	5.40		
	Nov. 6	3,368	385		2,983		1,608	1055	47.74	53.91	6.60	5.00	221.5	6.58	13.77	33.4	33.4	33.1		5.00	6.60		6.7
Chinese sorghum, topped and stripped.	Sept. 23	319	76		243		111	1066	34.80	45.68	11.30	2.80	17.3	5.43	15.60	57.4	57.9	16.4		2.80	11.30		2.2
Chinese sorghum, topped but not stripped.	Oct. 2	296		49		247	139	1060	46.96		11.60	2.30	20.0	6.76	14.39	46.3	54.4	18.3	16.46	2.30	11.60	8.90	8.7
	Oct. 11	1,679		187		1,492	542	1060	32.28		5.58	8.06	74.9	4.46	13.82	26.3	27.8	57.5	15.18	8.06	5.58	4.80	8.3
	Oct. 25	1,709		245		1,464	562	1058	32.88		5.01	4.89	77.7	4.55	13.82	36.0	35.8	39.1		4.89	5.01		2.8
Liberian sorghum, topped and stripped.	Aug. 28						20																
	Nov. 7	2,544	454		2,090		1,009	1072	36.66	48.28	10.54	4.62	186.4	7.33	18.47	48.0	47.5	24.2		4.62	10.54		3.3
Pearl millet, topped and not stripped.	Oct. 2	378		31		347	106	1047	28.04		6.60	1.60	10.2	2.71	9.66	39.3	47.2	17.2	15.16	1.60	6.60	4.60	7.2
	Oct. 10	437		44		393	131	1047	30.00		6.36	1.49	12.4	2.84	9.48	41.4	46.8	12.7	10.03	1.49	6.36	3.50	2.3
Field corn, topped and stripped.	Sept. 29	222	67		155		70	1070	31.53	45.16	10.90	2.40	9.5	4.28	13.56	52.7	62.0	12.6	15.01	2.40	10.90	10.05	
	Oct. 4	1,969	667		1,302		494	1035	25.09	37.94	5.40	2.30	46.0	2.34	9.31	36.9	48.1	23.9	9.43	2.30	5.40	4.06	3.3
	Oct. 7	1,519	493		1,026		384	1043	25.28	37.43	4.80	3.70	39.6	2.61	10.31	27.3	39.8	31.3		3.70	4.80		.5
	Oct. 8	1,498	472		1,026		395	1040	26.37	38.50	5.10	3.80	40.5	2.71	10.26	21.4	34.5	36.4	18.79	3.80	5.10		8.6
	Oct. 13				1,095		332	1038		30.32	2.70	4.48	36.1		10.87	18.5	25.5	42.0	8.07	4.48	2.70		.0
Egyptian sugar-corn, topped and stripped.	Sept. 11	621	240		381		159	1063	25.60	41.73	8.25	2.85	30.3	4.89	19.08	52.9				2.85	8.25		
Stowell's Evergreen corn, topped and stripped.	Oct. 16	3,435	1,035		2,400		1,123	1042	32.69	46.79	8.28	1.19	132.0	3.84	11.75	37.8	20.9	26.1	11.91	1.19	8.28		42.9
	Oct. 17	4,185	1,261		2,924		1,395	1042	33.33	47.71	7.35	1.25	157.3	3.76	11.27	11.5	18.8	41.6	11.24	1.25	7.35	5.10	54.4
	Oct. 18	1,968	593		1,375		612	1044	31.10	44.51			68.8	3.50	11.25	44.3	46.7	17.2					
Miller's sweet corn, topp'd and stripped.	Sept. 17	760	281		479		214	1042	28.16	44.68	5.20	3.80	24.2	3.21	11.39	38.1	45.3	31.2		3.80	5.20		.0
	Sept. 18	1,407	527		880		445	1051	31.63	50.57	7.40	4.20	57.6	4.09	12.94	38.1	45.3	31.2	16.24	4.20	7.40		4.6
	Sept. 19	1,191	441		750		254	1051	21.33	33.87	7.90	4.50	48.8	4.10	19.23	38.1	45.3	31.2		4.50	7.90		4.5
Miller's sweet corn, topp'd and not stripped.	Sept. 20	821		111		710	268	1048	32.64				31.9	3.88	11.88	38.1	45.3	31.2					
	Sept. 25	1,001		154		847	294	1047	29.40		6.50	3.70	33.0	3.31	11.24	38.7	44.9	30.9	9.39	3.70	6.50		4.5

The apparatus used in the experiments, besides a few barrels and pails for holding the juice, consisted of a copper tank of the following dimensions: 4 feet 3 inches long, 2 feet 3 inches deep, 2 feet 3 inches wide; a galvanized iron pan 9 feet long 8 inches deep, 3 feet 6 inches wide. This iron pan was surrounded by a wooden frame of 2-inch plank so as to support the sides, and each pan was placed in brickwork with chimney, and so arranged as to permit a fire to be kept below it in direct contact with the bottom. In the case of the copper tank the flame played about the sides also, so as to heat the contents more rapidly. The galvanized iron pan was such as could readily be constructed by any ordinary tinsmith or mechanic. The copper tank was used for defecation with lime; the galvanized iron pan for evaporation. The process, in brief, is as follows: after topping and stripping the corn or sorghum, it was passed through the mill, and when sufficient juice had been obtained it was heated in the copper tank to a temperature of 82° C. = 180° F. After the juice had reached this temperature, there was added to it, with stirring, cream of lime, until a piece of litmus paper dipped in the juice showed a purple or bluish-purple color. The heat was now raised to the boiling point, and, so soon as the juice was in good ebullition, the fire was drawn and a thick scum removed from the surface of the juice. After a few minutes the sediment from the juice subsided, and by means of a siphon the clear liquid was decanted off, leaving a muddy sediment, which was equal to about one-tenth to one-twentieth of the bulk of the juice. It was found that by means of the stop-cock at the bottom of the defecatar, it was possible to draw off the clarified juice more thoroughly than by means of the siphon, so that this method has been adopted for removing the juice. It is only necessary to collect in a separate vessel the first portions of juice coming from stop-cock, which are turbid, and passing this through the bag filter with the sediment. This muddy sediment was then drawn off by means of a stop-cock and filtered through a plaited-bag filter, and the clear filtrate therefrom was added to the liquid previously siphoned off. The clarified juice, which, during the above operation, is not allowed to cool below a temperature of 66° C. or 150° F., was now emptied into the evaporating pan, and there was added to it, with stirring, a solution of sulphurous acid in water until the lime present was neutralized, as was shown by the reddening of litmus paper when it was dipped in the juice. The evaporation was now hastened as much as possible, and the juice concentrated to a sirup at a boiling point of 112° C., equal to 234° F., or thereabout. During the close of the evaporation there is great danger of scorching the sirup, and this was obviated by allowing only coals beneath the evaporator and briskly stirring the syrup by means of paddles 8 or 10 inches wide. When the sirup reached the density above indicated it was drawn off into wooden tubs, the fire having previously been drawn from beneath the evaporator.

It is doubtless true that many failures result in securing a crystallizable sirup even from good juice, owing to the operations of pressing of the cane, defecation, and evaporation being too much protracted. In order that those wishing to enter upon this industry may know what is practically attainable, even with common appliances, the following data are given.

In experiment No. 3, 2,107 pounds of topped stalks of Early Amber cane were pressed by the mill in 3½ hours, yielding 975 pounds of juice. The time required for heating the juice, defecation with lime, and evaporation to sirup was 5¾ hours. In order that the inferior character of the material supplied for these experiments might be known, specimens were taken from the several lots of stalks in experiments Nos. 1, 2, 3, 4, and it was found that the average weight of the stalks in these lots was four ounces each.

In most of the experiments above recorded the juice was raised to the temperature of 82° C. (180° F.), and then neutralized with milk of lime, but several experiments were made to learn the effect produced by neutralization with lime at different temperatures.

In experiment No. 4 the juice was divided into two portions, and the lime was added to the one portion at 40° C. (104° F.); to the other portion at 25° C. (77° F.), and the portions were separately evaporated to sirup.

In experiment No. 13 the lime was added directly after the juice was obtained from the mill, the temperature being 16° C. (61° F.).

In experiment No. 18, the lime was added at 80° C. (176° F.).

In the above-mentioned experiments the results were entirely satisfactory, and seem to indicate that the neutralization by means of lime may be effected at any stage below 82° C. No experiments were made in neutralizing at higher temperature than 82° C.

An experiment was also made to determine whether splitting the canes before they were passed through the mill would increase the percentage of juice obtained from the stalks. One hundred pounds of butt ends of Honduras sorghum were split lengthwise and then passed through the mill. Another parcel of one hundred pounds of butts of the same variety of sorghum, equal in all respects to the previous lot, was passed through the mill without splitting them. The results obtained were as follows: Percentage of juice obtained from split stalks, 54 per cent.; percentage of juice obtained from unsplit stalks, 57 per cent., from which it would appear that in this case, at least, the previous splitting of the stalks occasioned an appreciable loss in juice.

In plate 27 the apparatus used in these experiments is figured, showing the relative position of mill, pans, &c.

Two pans only are represented as being in use, viz: the defecating pan upon the left hand in the wood-cut and the evaporator upon the right hand. The stop-cocks by which the contents of the defecating pan are removed is not shown in the plate, being concealed by the small evaporator in front. A space of about two feet separates the brick work underneath the several pans, permitting one to pass easily about them.

The apparatus represented in the rear is used for making sulphurous acid solution, and consists of a small-sized hot water tank for kitchen range, about 40 inches long and 10 inches diameter. Into this powdered charcoal and oil of vitriol are put, and the sulphurous gas is passed through iron pipes into a wash-bottle containing oil of vitriol, and from thence into a barrel nearly filled with water. A safety tube is connected with the wash-bottle to prevent any possible rushing back of the water into the generator in case of the withdrawal of the heat. By this apparatus a barrel or two of the solution may be made in a short time and at an expense not over 75 cents per barrel. For two barrels there would be required 75 pounds of oil of vitriol and 7 pounds of powdered charcoal.

A few of the experiments made give a reasonable basis for estimating the probable yield of sirup and sugar to the acre; and, therefore, an approximate estimate of the cost of producing sugar.

Below is a tabulated result of a few of the experiments from stalks grown upon the grounds of the department. These stalks were grown in rows 3 feet apart, and in drills, and although a good crop, there is no doubt but that upon good land the estimated yield to the acre could be obtained:

	Pounds stalks from acre.	Sirup obtained.	Sirup, juice at best.	Sirup, juice = 70 per cent.
Chinese sorghum	38, 600	2, 096	2, 397	3, 673
Liberian sorghum	33, 727	2, 472	2, 609	3, 783
Early Amber sorghum	32, 415	2, 100	2, 615	3, 661
Honduras sorghum	66, 151	3, 652	5, 168	7, 537
Pearl millet	65, 000	1, 846	3, 128	4, 865
Field corn	27, 240	1, 166	....	1, 807

The first and second columns give the results actually secured, but the several juices were not in their best condition as compared with the results given in the first table. The third column is the amount of sirup the same weight of stalks would have yielded had they been cut at the proper time. The juice obtained from the stalks by the imperfect means at command of the department was little more than half the amount present in the stalks.

The fourth column represents the results attainable by the use of a mill that would give 70 per cent. of juice from the stalks; a result which is possible, and which is claimed by manufacturers of mills.

There is no doubt but that, when the present industry shall have secured the employment of the capital and scientific ability which has developed the beet-sugar industry, even these results, which may appear extravagant to many, will be assured.

Although, as has been stated, these sirups were obtained from stalks in which the maximum content of sugar had not yet been developed, they did, however, all crystallize well, and all yielded excellent sugar.

At the present the sugar has been separated from but the Chinese sorghum sirup, which yielded in the first crop of crystals 54.7 per cent. of its weight in sugar; the Early Amber sirup, which yielded 47.5 per cent. of sugar; and from the field-corn sirup, which yielded 39.3 per cent. of sugar. This latter experiment is worthy of especial mention, since the result secured is not only most surprising, but contrary to an almost universal belief. The corn-stalks used were of three varieties: Lindsay's Horse Tooth, Improved Prolific, and White Dent; three coarse-growing white field corns. The stalks grew in drills 3 feet apart, and about 9 or 10 inches apart in the drill. The ears were plucked after they had thoroughly ripened, and the husks were dead and dry. The corn was plump and sound, and yielded at the rate of 69.1 bushels of shelled corn (56 pounds to the bushel) to the acre. The stalks were then topped, stripped, and crushed, and the juice proved to be the best juice yet obtained from corn-stalks, at any period of growth or of any variety.

Below are given the results of the examination of the stalks of Egyptian sugar-corn, Honduras and Early Amber sorghums, and the leaves from the same. This examination was made for the purpose of determining the loss of sugar in the method employed in its extraction, also to determine the relative nutritive value of the leaves and stalks, pressed and unpressed. The stalks selected were split lengthwise, so that a fair average might be taken, and one-half was dried thoroughly without pressing, and the other half was passed through the mill, and the bagasse, or pressed stalks, carefully saved and dried.

Leaves, stalks, and bagasse from corn and sorghums

	Weight fresh.	Weight bagasse.	Weight juice.	Per cent. juice.	Weight dry.	Per cent. water.
Egyptian sugar-corn, leaves	380	......	......	....	116.6	67.3
Egyptian sugar-corn, one-half of 4 stripped stalks, unpressed	832	......	......	....	126.0	84.9
Egyptian sugar-corn, one-half of 4 stripped stalks, pressed	875	460	415	47.43	99.0	88.7
Honduras sorghum, leaves	432	......	......	....	100.8	76.7
Honduras sorghum, one-half of 2 stripped stalks, unpressed.	1,428	......	......	....	285.3	80.0
Honduras sorghum, one-half of 2 stripped stalks, pressed	1,390	724	666	47.91	222.7	84.0
Early Amber sorghum, leaves	399	......	......	....	99.7	75.0
Early Amber sorghum, one-half of 3 stripped stalks, unpressed.	651	......	......	....	157.9	75.7
Early Amber sorghum, one-half of 3 stripped stalks, pressed.	905	458	447	49.39	147.8	83.7

A determination of the proximate constituents of the dried leaves, stalks, and bagasse is given below, from which it will appear that there still remains a large amount of sugar in the bagasse which the process employed failed to remove from the cane or stalks, also that the per cent. of starch compounds is greater in the pressed than in the unpressed stalks, and that the percentage of nitrogenous matter remains nearly the same. Since the nutritive value of the pressed stalks is nearly if not quite equal to that of the umpressed stalks, weight for weight, and as they are left in a mechanical condition suitable for their preservation as green fodder by the system of ensilage, it would appear desirable that experiments be made leading to their utilization for this purpose.

Proximate analyses of stalks, bagasse, and leaves of sweet corn and sorghum, calculated to the dry substance.

	Unpressed stalks, Early Amber sorghum.	Unpressed stalks, Honduras sorghum.	Unpressed stalks, Egyptian sugar-corn.	Bagasse of Early Amber sorghum.	Bagasse of Honduras sorghum.	Bagasse of Egyptian sugar-corn.	Leaves of Early Amber sorghum.	Leaves of Honduras sorghum.	Leaves of Egyptian sugar-corn.
Organic acid, chlorophyll, color.	7.36	5.39	2.85	1.47	2.01	1.11	1.46	3.29	1.48
Wax	.94	.33	.44	.35	.84	.40	5.05	1.67	.54
Brown resin	6.98	6.00	8.11	5.11	3.53	5.75	7.91	6.67	5.20
Sugars	34.73	38.14	26.01	19.36	21.77	10.08	8.58	9.37	8.21
Gum	2.14	1.57	1.38	2.04	2.20	1.33	3.82	2.78	4.54
Starch isomers	20.34	17.67	22.44	31.46	26.27	23.16	14.49	21.22	24.77
Albuminoids	4.95	4.81	6.90	3.96	3.87	6.04	13.14	10.43	11.34
Alkali extract, by difference.	....	5.15	6.09	13.35	15.10	22.26	12.08	11.98	12.65
Crude fiber	16.01	16.48	19.82	19.10	20.66	25.00	17.98	18.51	20.83
Ash, by ignition	6.55	4.46	5.96	3.80	3.75	4.87	15.49	14.08	10.44
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

By reference to the two preceding tables, it will be seen that a very large percentage of the sugar was lost by the method employed in its production.

The amount of sugar in the Early Amber cane, dry, is to the amount present in the Early Amber bagasse, dry, as 100 is to 55.74.

In Honduras cane, dry : Honduras bagasse, dry : : 100 : 57.08.

In Egyptian sugar-corn, dry : Egyptian sugar-corn bagasse, dry : : 100 : 38.75.

As will be seen from these analyses—

	Per cent. sugar.
The Honduras cane, fresh, contained	7.62
The Early Amber cane, fresh, contained	8.42
The Egyptian sugar-corn, fresh, contained	3.94

while the sugar remaining in the bagasse, calculated to the fresh cane which produced these bagasses, gave as follows:

	Per cent. sugar.
Honduras sorghum	3.49
Early Amber sorghum	3.16
Egyptian sugar-corn	1.14

In other words, it will appear that there was occasioned a loss of—

46.4 per cent. of the sugar present in Honduras sorghum.

37.4 per cent. of the sugar present in Early Amber sorghum.

28.9 per cent. of the sugar present in Egyptian sugar-corn.

The importance, therefore, of a good mill cannot be overestimated, and it is desirable that efforts be made to devise some process by which results approximating those obtained in the extraction of sugar from beets shall be attained, since it is obvious that should the beet-sugar industry be conducted in so wasteful a manner as is the production of sugar from cane or from sorghum, this important industry could not survive a year, even in those countries most favorably circumstanced in regard to the production of beet sugar.

For convenience the following results which were obtained last year are appended, since these experiments were only confirmed this year, but the results have not been tabulated.

In the experiments made with corn-stalks the stalks were invariably stripped, the tops being cut off at about the second joint. The percentage of stripped stalks, leaves, and tops is given in this table:

Corn-stalks.	Per cent. of stripped stalks.	Per cent. of leaves and tops.
No. 1	67.57	32.43
No. 2	58.69	31.31
Nos. 3 and 4	67.46	32.54
Average	67.91	32.09

In those cases where the sorghum was stripped and topped the following percentage of stripped stalks and of leaves and tops was obtained:

Sorghum.	Per cent. of stripped stalks.	Per cent. of leaves and tops.
No. 5	72.67	27.33
No. 6	72.55	27.45
Average	72.61	27.39

On account of the trouble in stripping the stalks, experiments were made with stalks unstripped, the tops alone being removed, and these experiments appear to prove that this troublesome operation of stripping may be avoided without any diminution of the amount of juice or of sugar obtained therefrom.

Below are the results obtained from stripped and unstripped sorghum, calculated to the raw stalks used.

By raw stalks is meant the stalks as they were cut in the field, leaves, tops, and all.

	Average per cent. of juice to raw stalks.	Average per cent. sirup in juice.
Stripped sorghum, two experiments	35.02	15.00
Unstripped sorghum, five experiments	40.60	15.47

From the above it will be seen that not only was an increased amount of juice obtained, but that this juice gave an increased percentage of sirup, and there appears nothing unusual in the treatment of this juice from the unstripped cane, nor was there any appreciable difference in the readiness of the sirup to crystallize, nor in the character of the sugar finally obtained.

Although perhaps further experiments are desirable before considering this point as settled, it would appear from the above that not only was stripping unnecessary, but that it really involved a loss in the amount of sugar to be obtained; at least the above results indicate a difference of twenty per cent. increase in product in favor of the unstripped cane. It is not improbable that the above result is due to the fact that the leaves in passing through the mill tended to fill up the interstices between the compressed cane, and thus prevented the expressed juice from flowing through between the rolls with the bagasse. In case of discoloration by action of moisture or other causes, it will, however, be advisable, and probably necessary, to strip the stalks.

Several experiments were also made with both corn-stalks and sorghum to determine the relative value of the upper and lower half of the stalks, with the results given in the following table:

	Percentage of juice to stalks.	Specific gravity of juice.	Percentage of sirup in juice.
Corn-stalks, butt ends, No. 3	29.04	1053	14.62
Corn-stalks, top ends, No. 4	19.94	1050	13.46
Sorghum, butt ends, No. 8	47.49	1059	16.41
Sorghum, butt ends, No. 10	41.49	1062	16.47
Sorghum, top ends, No. 9	43.16	1057	14.70
Sorghum, top ends, No. 11	34.09	1059	14.26

Nos. 8 and 9 were the butts and tops of the same stalks, and were cut just after a rain, as were also Nos. 10 and 11, from which the rain had evaporated, and the difference in yield of juice and sirup between butts and tops is nearly constant. The increase in specific gravity of the juice from butts over that from the top is also worthy of notice.

From the above table the conclusion from the average results is, that the proportion, by weight, of sugar in the lower half of the stalk is to the sugar in the upper half as follows: Corn butts to corn tops as 159 to 100; sorghum butts to sorghum tops as 131 is to 100. As will be seen by reference to the first table, the stalks of both corn and sorghum in the above experiment were divided almost equally by weight into butts and tops, so that the above proportion fairly represents the proportion of yield of sugar in the upper and lower half of the cane. There was a marked difference in the appearance of the juice as it flowed from the mill (that from the butts being lighter in color, especially in the experiments with corn), but after clarification no appreciable difference could be observed, nor was there any difference in the product except the quantitative one above mentioned, which was, however, a marked difference. Also, there was a marked difference in granulation in favor of the juice from the butts.

The experiments of this year (1879) doubtless explain some of the results of the previous year; since it is probably true that, owing to immaturity, the tops had not yet attained their maximum content of sugar. A study of the previous tables giving results of the analysis of sorghums shows that up to a certain period the lower half of the cane is the best, but that this does not remain true of the sorghum, as it does of the sugar-cane in Louisiana, since the sorghum does have time to completely mature, which is not true of the sugar-cane in our country.

In the following table there have been calculated from the results given of the experiments in the making of sugar the following:

1st. The percentages of the sugar present in the juices operated upon, which were obtained in the sirup.

2d. The percentage of crystallizable sugar (sucrose) present in the juices which was obtained in the sirup.

3d. The percentage of uncrystallizable sugar (glucose) present in the juices, which was obtained in the sirup.

4th. The percentage of crystallizable sugar present in the juices, which was inverted by the process of manufacture.

5th. The percentage of uncrystallizable sugar (glucose) destroyed during the process of manufacture.

The presence of the same relative proportions of crystallizable and uncrystallizable sugar in a sirup to those present in the juice from which this srup has been prepared, by no means implies that there has been no inversion of the crystallizable sugar; for the destructive action of an excess of lime upon glucose is well known and is not unfrequently made available in the production of sugar. Hence it not unfrequently happens that the relative quantity of crystallizable sugar in the sirup may be greatly in excess of that present in the juice, even after a large quantity of the crystallizable sugar has been destroyed by inversion. It is only possible then to determine the character of the changes which have taken place in the sugars during the process of manufacture, by quantitatively determining the amounts of sucrose and glucose in the juices and in the sirups prepared from them.

Since, obviously, this is a question of the greatest practical importance, as bearing upon the profitableness of the production of sugar from corn-stalks or sorghum, the tables following will be studied with interest by those engaged in this production.

As will have been observed in the previous table, there is a constant but not uniform discrepancy between the polarization of the sirups and the amount of crystallizable sugar found present by analysis.

Almost invariably the amount of sucrose found present is somewhat in excess of the amount indicated by the polariscope, and this variation is such as to forbid any supposition that it is the result of error in observation or in analytical work.

This explanation may be found by consulting the following tables, by which it appears that, although there is generally about the same amount of glucose in the sirups relative to the amount present in the juice (averaging 97.1 per cent.), there is still evidence of the destruction of an average of 35 per cent. of the glucose. This destruction of glucose appears to be compensated, in part, by the inversion of a certain portion of the crystallizable sugar, and this inverted sugar possesses such action upon the polarized ray as to render the results of the polariscope practically worthless.

Practically, it appears that the proportion of crystallizable sugar present in the juice, which may be obtained in the sirup, depends greatly upon the condition of the stalks when worked. For, as will be seen, the average amount secured in all these experiments was but 77.1 per cent., still in those sirups prepared from canes which were in the proper condition the amount was over 90 per cent. of the crystallizable sugar present in the juice operated upon. (See experiments Nos. 6 and 7.) It is not improbable that even better results may be secured after further experiments shall have perfected the process of manufacture; but in view of the fact that such results have been attained with such crude and simple apparatus as that employed in the experiments here recorded, this result is highly gratifying.

We may hope then to secure in sirup 90 per cent. of the crystallizable sugar present in the juice operated upon.

Number.	Per cent. of sugars in sirup of amount present in juice.	Per cent. of sucrose in sirup of amount present in juice.	Per cent. of glucose in sirup of amount present in juice.	Per cent. of sucrose inverted of amount present in juice.	Per cent. of glucose destroyed in process of making.
1	....	....	....	....	....
2	82.3	66.7	138.3	33.3	0.0
3	74.7	66.1	102.1	33.9	31.8
4	83.3	76.0	106.0	24.0	18.0
5	85.1	80.2	107.8	19.8	12.0
6	94.4	89.1	120.9	10.9	....
7	92.9	91.7	103.6	8.3	4.7
8	77.4	57.7	127.7	42.3	14.6
9	89.5	87.1	96.5	12.9	16.4
10	91.8	95.7	90.7	4.3	13.6
11	79.0	69.7	91.2	30.3	39.1
12	82.1	79.8	91.3	20.2	28.9
13	80.4	67.5	114.5	32.5	18.0
14	86.4	68.9	98.6	31.1	32.5
15	95.6	98.7	110.6	1.3	....
16	....	....	....	....	....
17	87.4	83.3	96.7	16.7	20.0
18	75.5	68.8	103.5	31.2	27.7
19	71.8	69.7	80.4	30.3	49.9
20	76.1	77.2	71.3	22.8	51.5
21	87.2	82.9	96.8	17.1	20.3
22	86.3	85.6	87.2	14.4	27.2
23	90.8	69.3	98.3	30.7	32.4
24	....	....	....	....	....
25	102.2	102.7	102.0	....	....
26	58.3	29.7	25.8	70.3	144.5
27	79.2	28.8	37.5	71.2	133.7
28	....	....	....	....	....
29	96.1	98.5	92.8	1.5	8.7
30	85.4	79.2	96.1	20.8	24.7
31	118.5	110.1	133.2	....	....
32	....	....	....	....	....
33	84.9	77.5	93.7	22.5	28.8
Average	85.5	77.1	97.0	24.2	34.7

The results obtained in the experiments made with stalks from Stowell's Evergreen Sweet Corn are most remarkable and demand explanation. It will be seen that the juice obtained from these stalks gave in the laboratory excellent results, and promised a sirup of fine quality. By reference to the tables it will be seen, however, that these sirups (see experiments Nos. 26 and 27) were wholly abnormal and very disappointing. These stalks were cut in Frederick, Md., October 11, packed in a close car, and, through an oversight, allowed so to remain during oppressively hot weather until the 15th. They were worked up on the 16th, 17th, and 18th. Upon their arrival at Washington they were found so heated as to render their removal from the car even difficult, and yet, as will be seen, the juice expressed from them appeared of excellent quality, but every attempt to produce from it a crystallizable sirup failed. and an analysis of the sirup showed that a very large percentage of the sugar had been inverted (in experiments Nos. 26 and 27), and that the destruction of glucose in the sirup had been unusually large, while the amount of crystallizable sugar present in the juice, and recovered in the sirup, was less than 30 per cent.

A few of the results attained appear to be only explicable upon the supposition that there have been slight errors in analysis, but revision of the work fails to reveal such errors, and the results are given in full without omission, hoping that future investigation may enable us to solve difficulties which at present appear irreconcilable.

Comparison of the upper and lower halves of sorghum-canes.

	Per cent.
Average per cent. of water in 17 specimens of Chinese sorghum.......tops..	73.05
Average per cent. of water in 16 specimens of Chinese sorghum......butts..	74.46
Average per cent. of water in 20 specimens of Honduras sorghum....tops..	72.57
Average per cent. of water in 20 specimens of Honduras sorghum...butts..	76.15
Average per cent. of water in 23 specimens of Liberian sorghum......tops..	71.67
Average per cent. of water in 23 specimens of Liberian sorghum....butts..	75.22
Average per cent. of water in 22 specimens of Early Amber sorghum...tops..	72.73
Average per cent. of water in 22 specimens of Early Amber sorghum.butts..	72.13
Average per cent. of juice from 10 specimens of Chinese sorghum.....tops..	45.17
Average per cent. of juice from 10 specimens of Chinese sorghum...butts..	49.89
Average per cent. of juice from 16 specimens of Honduras sorghum...tops..	42.88
Average per cent. of juice from 17 specimens of Honduras sorghum..butts..	45.44
Average per cent. of juice from 13 specimens of Liberian sorghum.....tops..	42.63
Average per cent. of juice from 13 specimens of Liberian sorghum...butts..	44.50
Average per cent. of juice from 11 specimens of Early Amber sorghum..tops.	46.68
Average per cent. of juice from 11 specimens of Early Amber sorghum.butts..	50.58
Average specific gravity of juice from 17 specimens of Chinese sorghum, tops..........	1.0725
Average specific gravity of juice from 17 specimens of Chinese sorghum, butts..........	1.0708
Average specific gravity of juice from 21 specimens of Honduras sorghum, tops..........	1.0602
Average specific gravity of juice from 21 specimens of Honduras sorghum, butts..........	1.0584
Average specific gravity of juice from 24 specimens of Liberian sorghum, tops..........	1.0753
Average specific gravity of juice from 24 specimens of Liberian sorghum, butts..........	1.0730
Average specific gravity of juice from 22 specimens of Early Amber sorghum, tops..........	1.0765
Average specific gravity of juice from 22 specimens of Early Amber sorghum, butts..........	1.0771
Average per cent. of solid matter in juice from 16 specimens of Chinese sorghum..........tops..	16.21
Average per cent. of solid matter in juice from 17 specimens of Chinese sorghum..........butts..	16.81
Average per cent. of solid matter in juice from 19 specimens of Honduras sorghum..........tops..	13.85
Average per cent. of solid matter in juice from 20 specimens of Honduras sorghum..........butts..	13.82
Average per cent. of solid matter in juice from 23 specimens of Liberian sorghum..........tops..	16.91
Average per cent. of solid matter in juice from 22 specimens of Liberian sorghum..........butts..	16.71
Average per cent. of solid matter in juice from 19 specimens of Early Amber sorghum..........tops..	17.59
Average per cent. of solid matter in juice from 21 specimens of Early Amber sorghum..........butts..	16.75

	Per cent.
Average per cent. of water in tops, 79 specimens	72.45
Average per cent. of water in butts, 79 specimens	74.51
Average per cent. of juice from tops, 50 specimens	43.96
Average per cent. of juice from butts, 51 specimens	46.90
Average per cent. of solids in juice from tops, 77 specimens	16.18
Average per cent. of solids in juice from butts, 80 specimens	16.02
Average specific gravity of juice from tops, 84 specimens	10.71
Average specific gravity of juice from butts, 84 specimens	10.70

From the above comparison it will appear that there exists no marked difference in the amount of juice present in the upper and lower halves of the canes, nor in the quality of this juice as indicated by either the relative specific gravities or the total amount of solid matter present in the juices.

But by reference to the previous tables, giving the results in detail, the fact will appear in the case of each of the sorghums examined that, during the early stages of development of these plants, the total sugars present in the juices is comparatively low, often not one-third of the maximum afterwards found in the plant, and consequently the amount of sirup possible to be made from this immature cane is proportionately less than that which the same stalks would yield when fully matured.

It will also appear that, during this early and immature state of the plant, the relative amount of crystallizable sugar (sucrose) as compared with the total sugars present is much greater in the lower half of the canes. This condition remains, apparently, until the seed has reached the milky state, at which time the juices in both parts of the plant appear to be of equal value. But it must not be understood that the maximum content of sugar in the plant has been reached at this period of development, since, as will be seen by the tables, this is far from the fact.

From this period in the plant's development until the perfect ripening of the seed, the juices appear to uniformly increase in their content of crystallizable sugar, and to decrease in their content of uncrystallizable sugar.

Still later in the history of the plant there appears a slight deterioration in the quality of the juice from the lower half of the stalk, and it is found generally to be somewhat inferior to the juice from the upper half.

It appears probable that this deterioration of the juice from the lower part of the cane marks the incipient stages of death and the ultimate decay of the plant, the roots and leaves failing in their office to supply the full amount of nourishment which the plant requires. It begins to feed upon itself, so to speak, and it is to be observed that at this period the off-shoots from the upper joints of the stalk begin a vigorous growth and appear to live as parasites upon the parent stalk.

It will appear also that at the first examinations the specific gravity of the juices from the lower half of the cane is almost invariably greater than that of the juices from the upper halves, and that an equality of specific gravity appears to indicate an equality between the juices in their content of sugar not only, but in its relative proportions of sucrose and glucose.

Proximate analyses have been made of the seed of two varieties of sorghum, the early amber and the Chinese, the results of which are given below. It will be seen that this seed differs but little in composition from the other cereals, and closely resembles corn, and it will doubtless prove valuable as food for farm stock.

	Sorghum seeds.	
	Early amber.	Chinese.
Moisture	10.57	9.93
Ash	1.81	1.47
Fat	4.60	3.95
Sugars	1.91	2.70
Albumen, insoluble in alcohol	2.64	2.64
Albumen, soluble in alcohol	7.34	6.90
Gum	1.10	.72
Starch, color, &c	68.55	70.17
Crude fiber	1.48	1.52
	100.00	100.00

Moisture was estimated from loss by drying at 105° C. Ash, by simple ignition; total albuminoids from total nitrogen multiplied by 6.25. Under "sugars" is given that portion of the 80 per cent. alcohol extract which was found soluble in water. The insoluble portion of this alcohol extract included a little red coloring matter, but otherwise seemed to be identical with the "zein" of maize. Gum was extracted by water, after use of ether and alcohol. Fat was extracted directly from the sample by absolute ether; it was yellowish, semi-solid, and very much resembled the fat similarly extracted from corn. Starch, color, &c., were determined by difference. In early amber there was found 64.05 per cent., and in Chinese sorghum 64.74 per cent. of starch by titration, with Fehling's solution of an acid extract made after extraction with ether, alcohol, and water.

Crude fiber is that portion, ash free, which still remains insoluble after treatment of the sample with ether, alcohol, water, dilute hydrochloric acid, and dilute potassic hydrate. It is usually white or slightly gray, and free from nitrogen.

Proximate analyses have also been made of the scum and sediment obtained in defecating the juice, with a view of throwing light upon the chemical character of this important process.

The results of these analyses are given below.

	Liberian lime precipitate.	Honduras lime precipitate.	Honduras skimmings.
Moisture	9.77	7.69	5.72
Ash	21.69	7.00	14.39
Chlorophyll and wax	17.60	8.95	14.44
Sugars	10.80	43.96	15.06
Resins and trace albumen	—3.61	3.26	5.08
Gum	6.02	11.40	11.10
Albuminoids	22.58	4.55	8.05
Humus-like substances, diff	—5.73	12.71	5.58
Crude fiber	2.20	.48	5.49
Starch isomers	Trace.	Trace.	15.18
	100.00	100.00	100.00

The large amount of ash in Liberian lime precipitate and Honduras skimmings is due to the presence of considerable clay, which had been used to hasten the clarification of the juice. There was little or no clay present in Honduras lime precipitate. The claying seems mechanically to have carried down a large proportion of the albumen in the Liberian lime precipitate.

The very great difference in these waste products is probably due almost wholly to differences in the manipulation of the juices.

Very probably there exists in lime precipitates a combined organic acid; this will be investigated in the future.

Whoever may detect error in the methods employed, or in the results stated, will confer a favor by mentioning the same.

It is certainly most desirable that these experiments be continued upon a larger scale, and with at least a dozen varieties of sorghum and an equal number of varieties of sweet, yellow, and white corn.

At least an acre of each variety should be grown, and the development of each should be watched through the season, and when the proper time for working up the crop has come, let the acre be worked up for sugar. Such an experiment would require little outlay and be productive of invaluable results. It would require at least three or four assistants additional in the chemical laboratory to attend to the continued analyses of the canes, and would necessitate a somewhat larger apparatus for working up the crop.

The correspondence addressed to this division upon this subject of sugar has steadily increased until it requires nearly all the time of one assistant to attend to it.

THE PERMANGANATE PROCESS FOR THE ESTIMATION OF SUGARS IN JUICES.

1. *Preparation of the juice.*

Usually two stalks were selected for analysis. Their maturity, as shown by the development of blossoms, seeds, and the color and condition of the glumes, was recorded. Then were noted—

a. The weight of the unstripped stalks.

b. The weight of the stripped and topped stalks, and, by difference, the weight of leaves and tops.

c. The average length and diameter of the stripped stalks.

These stripped stalks were then divided so that tops and butts were of equal weight. Then was found—

d. The average length each of tops and butts. The tops and butts were then separately analyzed. Each by itself was cut finely with a hatchet, and then bruised in an iron mortar. The bruised mass was then placed in a small bag, and submitted to a heavy pressure in an ordinary iron press.

The expressed juice was collected and weighed, and the percentage calculated to the unstripped stalks taken.

The juice thus obtained usually was greenish from the presence of chlorophyll. As the plant matured, the color of the juice inclined to amber, and in perfectly ripe stalks (especially of the Early Amber variety) the color was red, from the presence, in the central portion of the stalk, of a red coloring matter sparingly soluble in ether, readily dissolved by 80 per cent. alcohol.

The specific gravity of the juice was determined usually by a piknometer. It was found that the readings given by an accurate hydrometer accorded well with the specific gravity indicated by weight, if the juice was previously allowed to stand for about half an hour, to allow included air to escape.

A weighed portion of the juice was dried, at a heat not exceeding 100° C, until two successive weights showed but little variation; the percentage of residue thus found was stated as *total solids in juice.* These figures can be regarded only as fair approximations, for chemists are well aware of the difficulties attending the perfect desiccation of saccharine juices. In this connection, however, the results are valuable as checks upon the sugar determinations.

For determination of sugars in the juice 100 c. c. were taken, and made in every case to 125 c. c. by addition of solution of subacetate of lead and water. Among other substances precipitated by the treatment were chlorophyll, albumenoid matter, gum, and lead salts of the inorganic acids of the ash.

The liqid was filtered perfectly clear through dry paper, and was sometimes colorless and sometimes amber. Every 10 c. c. of this liquid represented 8 c. c. of the original juice.

For the determination of inverted sugar, 10 c. c. of this filtered liquor were taken, and for sucrose 5 c. c.

The portion for glucose was treated with considerable excess of Fehling's solution, and carefully heated on the water-bath, a thermometer being inserted in the liquid, which was not allowed to rise above 75° C. At this temperature perfectly pure sucrose does not reduce Fehling's solution in the least.

The portion for sucrose was inverted by boiling half an hour with slight excess of dilute hydrochloric acid. The inverted sugar thus formed was then treated with large excess of Fehling's solution, exactly as above described, except that it was not necessary to keep the temperature lower than the heat of the water-bath (100° C.).

The precipitated red suboxide of copper was then thoroughly washed with hot water by decantation and filtration (without aspiration usually) through fine paper. It was then dissolved in an acid (sulphuric) solution of ferric sulphate, and the amount of ferrous salt determined by titration with potassium permanganate.

This method for determining glucose depends upon the following facts:

1. That two molecules (360 parts by weight) of glucose ($C_6 H_{12} O_6$) will reduce from Fehling's solution five molecules of cuprous oxide ($5 Cu_2 O$).

2. That the five molecules of cuprous oxide thus precipitated will reduce in acid sol. five molecules of ferric sulphate ($Fe_2 (S O_4)_3$) to form ten molecules (1,520 parts by weight) of ferrous sulphate ($Fe. S O_4$) as is explained by the following equation:

$$\left\{\begin{matrix} 5 Cu_2 O \\ 715 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 5 Fe_2 (S O_4)_3 \\ 2{,}000 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 5 H_2 S O_4 \\ 490 \text{ parts} \end{matrix}\right\} = \left\{\begin{matrix} 10 Cu S O_4 \\ 1{,}595 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 10 Fe S O_4 \\ 1{,}520 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 5 H_2 O \\ 90 \text{ parts} \end{matrix}\right\}$$

The ten molecules of ferrous sulphate thus formed will decolorize one molecule (316.2 parts by weight) of potassium permanganate ($K_2 Mn_2 O_8$), thus:

$$\left\{\begin{matrix} 10 Fe S O_4 \\ 1{,}520 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} K_2 Mn_2 O_8 \\ 316.2 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 8 H_2 S O_4 \\ 784 \text{ parts} \end{matrix}\right\} = \left\{\begin{matrix} 5 Fe_2 (S O_4)_3 \\ 2{,}000 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 2 Mn S O_4 \\ 302 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} K_2 S O_4 \\ 174.2 \text{ parts} \end{matrix}\right\} + \left\{\begin{matrix} 8 H_2 O \\ 144 \text{ parts} \end{matrix}\right\}$$

By following this explanation, it appears that two molecules of glucose are exactly represented by one molecule of potassium permanganate, as will appear from the following, by omitting the second and third members of the series. Thus:

$$\left\{\begin{matrix} 2 C_6 H_{12} O_6 \\ 360 \text{ parts} \end{matrix}\right\} = \left\{\begin{matrix} 5 Cu_2 O \\ 715 \text{ parts} \end{matrix}\right\} = \left\{\begin{matrix} 10 Fe S O_4 \\ 1{,}520 \text{ parts} \end{matrix}\right\} = \left\{\begin{matrix} K_2 Mn_2 O_8 \\ 316.2 \text{ parts} \end{matrix}\right\}$$

In other words, 316.2 parts by weight of potassium permanganate are equivalent to 360 parts of glucose, or one part of permanganate corresponds to 1.1385 parts of glucose. If, then, the amount of permanganate decolorized be multiplied by 1.1385 it will correctly represent the amount of glucose present. So much for the theoretical explanation. In practice it is found that each chemist must determine for himself his titration error by estimations made upon sugar of known purity.

This individual error is due to the difficulty in determining the exact end reaction; experience has shown, in the course of this work, that the point where the color of the permanganate barely appears in the rapidly agitated liquid is nearly identical with the true end reaction. Some operators carry the titration a little further until a faint rose tint is permanent for about two seconds. Each man who has done this work has carefully determined his titration error, and all figures submitted have been corrected therefor. The iron solution works best if very strongly acidulated with sulphuric acid. The most convenient strength for the permanganate solution is 4.392 grams to the liter, equal to .005 grams glucose for each cubic centimeter.

In the earlier part of these determinations it was not considered necessary to thoroughly wash the precipitated suboxide of copper before dissolving it in the ferric sulphate solution. Carefully performed experiments, however, showed that washing was best, and that the results obtained on unwashed suboxide would equal those on the washed if multiplied by .9676 for glucose and by .9438 for sucrose.

As the results of much careful work it appears that, if the suboxide be well washed, and if each operator determines his titration error, the determination of glucose by this method is very accurate.

The amount of glucose found was divided by the weight of 8 c. c. of the juice analyzed for percentage of glucose. The sucrose was found by subtracting from the total glucose after inversion the amount originally present in 4 c. c. of the juice, and multiplying the remaining glucose by .95. The percentage was then calculated in the usual way.

Respectfully,

PETER COLLIER,
Chemist, Agricultural Department.

MACHINERY.

Replying to your inquiry relative to the different kinds of machinery for making sugar from sorghum, I would remark that the juices of the various kinds of sorghum examined by the department (and the same is true without doubt of all varieties of sorghum) are so nearly similar to the juice of the tropical sugar-cane (*Saccharum officinarum*) that the same machinery and the same processes will undoubtedly be as useful in the manipulation of the one as of the other.

Heretofore sorghum has been grown for the purpose of making sirup in almost every part of the country where corn would grow; and in this manufacture a certain class of machinery, known as sorgo-machinery, has become general. This machinery is simple and strong in structure, and as now made consists ordinarily of three rollers, which are either vertical or horizontal, and are driven by horse, steam, or other power. Having a capacity for work in proportion to the power employed and the size of the mill, and varying but little in construction, it is manufactured in all parts of the United States and can be obtained at low rates at almost any large machine-shop.

The cuts here presented in illustration of the leading classes of sugar-making machinery have been kindly furnished by two or three houses largely engaged in the manufacture; but machinery of like character is made in almost every county in the United States in which there is a large iron-working establishment. Whatever difference of opinion may exist relative to the comparative efficiency of the several mills and pans on the market must be decided by the individuals who wish to purchase. They will not and need not necessarily be confined to any special kind, as there are many desirable sorts for sale throughout the country. By way of comparison the illustrations embrace some that represent the primitive methods of sugar-making among the Hindoos and other nations.

The cost of a small outfit necessary to work up the product of the ten to fifty acres of sorghum that one or two farmers might raise in a neighborhood, would be from $150 to $500, while mills required in larger operations would, of course, necessitate a proportional increase in expenditure. The *plant* or apparatus commonly employed at this time in the manufacture of sorghum syrup consists of a small three-roller mill, for expressing the juice; one or more tanks for receiving it and heating it to a point where lime or other defecating agents may be used (if it be thought necessary to use them at all), and a shallow pan or two for evaporation. However, much fuller information on this subject than I can now give will be found in the proceedings of the convention of the Northwestern Sugar Growers' Association, before referred to.

In the practical manufacture of sugar, in a large way, from sorghum and corn-stalks, it will be found necessary, I have no doubt, to establish large central factories or mills, having the same relations to this industry as do the grist-mills of a neighborhood, to-day, to wheat and corn. Mills of this character should be capable of handling at least 500 acres of sorghum or corn during one season, and I am informed by manufacturers of machinery who have considered the subject with care that such mills may be built for a sum not exceeding $12,500, and that possibly this amount would also afford a margin for a fair working capital for the operations of a single season. This central factory would be able to work up not only the cane from 500 acres during a season, but also to rework into sugar the product of the small mills established at greater or less distances around it that had carried their operations no further than the manufacture of concentrated sirup, weighing, say, ten pounds to the gallon.

Probably it will be more profitable to the average farmer to simply convert the juice of his stalks into a sirup and sell it as such to a mill prepared for making sugar in a large way, with vacuum-pans and centrifugals, than it would be to work his cane into sugar himself. For although good sugar has been made during the past season by open-pan evaporation by small farmers in many parts of the country, and made at a profit, yet the time must come when the competition in the manufacture of sugar will be so great as to reduce the profits materially, and to demand the closest economy in all the various processes of cultivation and subsequent manipulation. Until, however, the supply shall begin to equal our home demand there will probably be a very fair profit to the average farmer with his small mill and open-pan evaporation in making sugar, molasses, and vinegar; for vinegar is one of the products of this industry which is of importance, the skimmings and other refuse making an excellent article that finds ready sale at remunerative prices.

The entire cost from the first breaking up of the land, and carefully counting every expenditure at the current cash prices of the country for labor and other things, the entire cost of production in the Western States, the past season, of a gallon of dense sirup, weighing say 13 pounds, did not exceed 16⅔ cents on an average. (It is quite possible to produce it at less cost.) These 13 pounds of sirup, if properly managed, should give from 6 or 8 pounds of sugar; and, if handled by the centrifugal, the sugar can be separated from the sirup at a fraction of one cent. per pound.

I am informed by Mr. Thoms, an experienced sugar boiler, employed last season at the Crystal Lake Sugar Works, Illinois, at which were made many thousand pounds of good sugar, that with trimmed cane delivered at the mill door, he can make and deliver the sugar at the mill for 1¼ cents per pound, a statement corroborated by Mr. Russell, of Janesville, Wis., late superintendent of the Crystal Lake Factory during the season of 1879.

The trimmed stalks can be bought for from $2 to $4 per ton delivered at the mill; and the farmer can very well afford to deliver them for this price, as he can raise from 15 to 30 tons per acre, and obtain besides a crop of seed equal in value to a fair crop of oats from the same number of acres, to say nothing of the large supply of excellent blade fodder. If we assume 20 tons of stalks per acre (and it is not too high an estimate for good land), the yield per acre would be from $60 to $80 delivered; and if the haul was not too long, this would be exceedingly profitable to the grower. If the haul should be so long as to preclude a profit, then it would be necessary for the farmer to have a small mill to reduce the juice to a dense sirup, as has been described, and to market it at the large factory in that condition.

Although a fair measure of success* has rewarded the efforts of many who were engaged, the past season, in the manufacture of sugar from sorghum, yet to obtain sugar uniformly and profitably from the juice of the various sugar-producing plants, under differing conditions of soil and seasons, experience is requisite as well as theoretic knowledge.

Instruction in this matter is of the utmost importance, and hence it is desirable that the Department of Agriculture should be authorized

* The following table is an epitome of the reports received by the department from those to whom the seed of the Early Amber cane was sent. Many of those reporting were entirely unaccustomed to the cultivation of this crop, and consequently were only partially successful. Others had the experience of some years to aid them, and from these the reports are uniformly favorable, and some remarkably favorable. A yield of at least 200 gallons of dense sirup per acre (worth 40 cents to 50 cents per gallon) it would seem reasonable to expect as the result of good seasons, good soil, good cultivation, and good milling.

State.	Average number gallons per acre.	Average value.	Number of people making sugar.	Price per pound.	Highest yield per acre.	Lowest yield per acre.
Alabama	122	$0 50	......	......	192	60
Arkansas	117	48	......	......	256	52
Colorado	116	90	......	......	124	109
California	196	50	1	......	200	192
Delaware	25	......	......	......	......	......
Dakota Territory	112	66	......	......	168	50
Florida	145	30	......	......	240	50
Georgia	104	48	......	......	192	42
Illinois	132	46	8	$0 10	325	40
Indiana	127	40	3	......	400	25
Indian Territory	127	75	......	......	200	82
Iowa	130	52	16	......	350	60
Kansas	114	49	7	......	300	25
Kentucky	119	39	2	......	244	31
Maryland	111	60	......	......	150	40
Michigan	166	51	2	......	480	75
Minnesota	138	56	5	......	376	43
Mississippi	111	49	......	......	500	32
Missouri	135	40	30	......	300	48
Nebraska	124	55	3	......	300	50
New Jersey	147	......	2	......	200	90
New York	175	75	2	......	214	136
North Carolina	163	57	3	......	176	40
Ohio	151	48	9	......	453	50
Pennsylvania	138	50	......	......	176	100
South Carolina	94	50	......	......	136	25
Tennessee	138	41	3	......	392	40
Texas	114	57	11	......	361	30
Utah Territory	117	62	1	......	150	98
Virginia	113	55	3	......	180	50
West Virginia	127	51	8	11	216	60
Wisconsin	149	54	17	......	260	60
	128	50	......	10.5	500	25

and empowered to make such experiments (at various central points, easily reached by those who are interested) as will practically instruct the people in all the various processes and machinery heretofore successfully used, and to discover, if possible, other and better methods of speedily obtaining the object in view, viz., the production of our own sugar and the consequent saving of the large sum annually paid for foreign sugar. The passage of Senate bill No. 1514 (referred to me) would enable the Department to institute important experiments in at least three localities that would go far to determine in a scientific manner the questions in the way of a speedy solution of the problem.

CONSUMPTION AND PRODUCTION.

Of your several inquiries there remains to be considered only the question of statistics relative to the consumption and production of sugar in the United States.

Perhaps I cannot make better reply to this inquiry than has already been made in my annual report for 1878. In that report the *consumption* from 1866 to 1878 inclusive for the entire country is given as follows:

	Pounds.		Pounds.
1866	1, 012, 799, 904	1873	1, 525, 974, 971
1867	870, 526, 017	1874	1, 705, 193, 954
1868	1, 195, 120, 413	1875	1, 859, 159, 674
1869	1, 309, 847, 125	1876	1, 604, 947, 164
1870	1, 306, 202, 065	1877	1, 731, 573, 553
1871	1, 327, 456, 300	1878	1, 991, 744, 160
1872	1, 565, 760, 616		

For the same years the *production* of cane sugar in the United States was as follows:

	Pounds.		Pounds.
1866	47, 150, 000	1873	102, 922, 700
1867	43, 294, 050	1874	134, 504, 691
1868	96, 894, 400	1875	163, 418, 070
1869	100, 153, 500	1876	190, 672, 570
1870	166, 613, 150	1877	147, 101, 941
1871	147, 730, 150	1878	257, 094, 160
1872	124, 798, 000	1879	210, 670, 000

In addition to this amount of sugar from cane there were produced, from 1866 to 1877 inclusive, 459,031,151 pounds of maple sugar.

The consumption of sugar for the year 1879 was within a small fraction of 40 pounds per capita of our population, being an increase of nearly 10 pounds per capita since the decade of 1860–'70 and of 15 pounds since the decade 1850–'60.

From these and other tables in our possession, it is found that over and above the amount of all sugars produced in the United States since 1849 we have consumed during the same period not less than eighteen hundred and odd millions of dollars' worth of foreign sugars and their allied products, or an amount of sugar more than equal in value to all the precious metals mined in the country since the discovery of gold in California, and nearly equal to the public debt at the present time. Estimating the population of the United States at 50,000,000, and multiplying this number by the pounds (40) per capita consumed in 1879, we have for the consumption of that year a total of 2,000,000,000 pounds. Of this amount 1,743,560,000 pounds, or more than 80 per cent., besides 38,395,575 gallons of molasses (the whole valued at $75,017,145, or, duty added, $114,516,745), were imported. To bring the vast amount of sugar imported into the country within more easy comprehension, we have only to imagine five vessels of nearly 500 tons each and loaded with sugar arriving daily at our ports each day in the year. To convey the whole amount consumed would require five trains of twenty cars each starting daily for one thousand days.

I have the honor to be, very respectfully,

WM. G. LE DUC,
Commissioner.

A.

ILLUSTRATIONS OF SUGAR PLANTS.

Of the following plates the first four represent varieties of sugar-cane grown, during the past season, on the grounds of the Department of Agriculture at Washington and used in the experiments of the Chemical Division, as detailed in Professor Collier's accompanying report. The drawings were made by a gentleman employed in the department. The designations given them are somewhat different from those current in some parts of the country, but are conformed to what are believed to be the most authoritative standards.

Plate I represents the Early Amber sugar-cane, the favorite variety with planters in Minnesota and the Northwest. What is now called the Minnesota Early Amber cane is claimed as an improvement upon the Early Amber varieties growing formerly in different parts of Minnesota, by Hon. Seth M. Kenny and Mr. C. F. Miller, of that State. Acting on the theory that cane in a high latitude will degenerate if grown continuously from its own seed, these gentlemen selected the finest specimens of seed from their own crops and sent them to a southern latitude to be grown. The seed product of this southern growth was returned to Minnesota. By this alternation of seed, and by other intelligent processes of culture, they have succeeded in establishing a new and permanent variety, which they claim to be more productive in weight of cane and to contain a higher per cent. of saccharine matter than any other grown in that State. This claim needs to be substantiated by more careful and extended observations before it can be said to be fully established.

Messrs. Kenny and Miller describe the Early Amber cane as presenting "the characteristics of both sorgo and imphee." By sorgo they mean the Chinese sorgo (Plate II), and by imphee, the White Liberian (Plate III), and its kindred African varieties. The Early Amber receives its name from its early ripening and from the bright amber color which characterizes its sirup when properly made. It is very rich in saccharine matter. When scientifically treated its products are destitute of that peculiar "sorghum" taste formerly complained of; the flavor is very similar to that of pure honey. The sirup readily granulates and yields sugar equal to the best ribbon cane of Louisiana.

The Early Amber cane on the department grounds did not grow quite so tall as the White Liberian. Its seed-heads were of moderate fullness and of very dark color.

Plate II shows the Chinese sorgo cane grown on the department grounds. Its height is about that of the Early Amber. Its seed-heads are fuller and more compact and somewhat resemble a head of sumac; hence the synonym "sumac cane." It is also known as "Chinese cane."

Plate III represents the White Liberian cane grown on the department grounds. This variety is rather taller than the Early Amber. The stalk curves at the top, leaving the head pendent; hence the synonym "Gooseneck." It is also styled a variety of the White Imphee. The seed-heads are shorter, more compact, and of lighter color than the Early Amber.

Plate IV shows the Honduras cane grown on the department grounds. It grows about one-half taller than either of the above varieties. Its seed-top is of reddish brown and spreading; hence its synonym "Sprangle Top." It is also called "Mastodon" and "Honey cane."

B.

MINNESOTA CANE GROWERS' CONVENTION.

A numerous and intelligent convention of the Early Amber cane growers and manufacturers of Minnesota was held at Minneapolis, January 22, 1880. The Commissioner had the pleasure of attending this convention and secured a phonographic report of its proceedings. As it embraced men of scientific attainments and of specific acquaintance with this new branch of productive industry, the discussions were remarkable for the vast number of facts and principles already accumulated in their experience. Of these it is proposed to furnish, here, an abstract showing the drift of opinion upon all the points of culture and manufacture.

SOIL.

There were some differences in the opinions expressed as to the availability of new land and, as usual in such cases, experiences varied. Some having expressed the fear that new land will impart a strong flavor to the cane-sirup, Mr. Wiley, who had large experience in both culture and manufacture, emphatically denied the fact. He said that while old land might produce a sirup of brighter color it was not at all better in taste. An advantage in using new timber land is found in the small amount of cultivation required. Costly culture on old land will not pay in opposition to cheap culture on new land. Mr. Wiley had paid as high as $15 per acre for hoeing. New land is comparatively free from foul seed and consequently less liable to a troublesome growth of weeds.

On the other hand Colonel Coleman, of the Saint Louis Rural World, and others contended that old land required less cultivation and produced better results. It was suggested that if it were necessary to clear old land of weeds or to fertilize it with barn-yard manure, a crop of corn should be grown upon it before planting the cane. The general opinion was in favor of a sandy upland soil, well drained, but not freshly manured.

In regard to manuring, facts were alleged to show that it spoiled the flavor of the sirup. A farmer had selected for his cane patch an old cow-yard. The stalks were tall and luxuriant, but the sirup would nearly "take off the skin of the mouth."

The great majority of opinion was in favor of the indefinite repetition of this crop on the same soil. The president of the convention mentioned the case of a neighbor who had cultivated the same ground most successfully for seven years without deterioration, his product ranging from 250 to 300 gallons of sirup per acre. Mr. Day and Mr. Dyer, of Hastings, corroborated this opinion from their own experience. The latter thought that his continued crops improved not only in quantity but also in quality.

The soil required for the cane is not necessarily very rich. A gentleman planted several knolls, too poor for wheat, in cane, and realized 200 gallons per acre of excellent sirup.

PREPARATION OF THE GROUND.

The general opinion was in favor of fall plowing. Mr. Farmer plows in August putting the plow to the beam. This caused all foul seed and especially pigeon grass to germinate in the fall and to be killed by winter freezing. Another advantage of fall plowing was that the crop was less liable to injury from droughts in the early season. Mr. Bozarth, of Iowa, after twenty-one years' experience in raising cane was decidedly in favor of fall plowing. In one case a portion of his cane patch, replowed in spring, yielded but half as much sirup as that which had been only fall plowed. On the other hand, Mr. E. A. Chapman, of Windham, had "demonstrated that a very large crop of cane can be raised the first year on the open prairie and at the first breakage." He had "broken 2 acres with the La Dow harrow, harrowing it completely, and it produced the best cane out of 5 acres." It was planted June 1, on black, loam soil. He believes that with the La Dow harrow "large crops can be raised on new breakings." "It did the work so well that several farmers got down on their knees to look at the soil; it looked so much like old soil." Those who practiced fall plowing were careful to stir the ground in the spring in order to destroy the weeds. Mr. Farmer, when the ground becomes sufficiently warm in the spring, goes over it with the Beaver Dam seeder and then with the drag and roller. This treatment effectually disposes of the grass, which point was generally considered of first importance.

TIME OF PLANTING.

There was some discussion on this point. The drift of opinion was expressed by the following resolution:

"*Resolved*, That the cane be planted as early as it is possible to work the ground properly, avoiding late frosts."

The ground should be well warmed before the seed is placed in it. In Minnesota the average seeding time is in the fore part of May, though several growers had been successful with plantings still earlier. The president of the convention thought that planting should not be quite so early on ground impregnated with grass seed. Mr. Wiley advised against planting till the season was warm enough to germinate the seed quickly. He had had later plantings which produced better than some earlier ones. A late spring frost might cut down early plantings and before they grew again the pigeon grass was apt to start up profusely. Mr. Wood had seen a field of cane some 8 or 10 inches higher than a neighboring field. He found that in the former case the seed had lain in the ground all winter and the latter had been planted early in spring. Experience and discretion were considered requisite to settle for each locality the exact time of planting as they are in all other cultures.

VARIETIES OF SORGHUM.

In a more southern latitude the cane grower may have considerable range of choice between different varieties, but for a locality so far north as Minnesota, the Early Amber, ripening within the productive season, is the only one that can be relied upon. The Commissioner of Agriculture, General Le Duc, by request, gave some very interesting facts in regard to the experiments with different sugar plants under the direction of the chemist of the department. The Early Amber cane was tested July 18, when the seed-head was just out, and showed 3.77 per cent. of glucose and 4.43 per cent. of sucrose. It was again tested August 16, 29 days afterwards, and found to contain but 1.54 per cent. of glucose, while the sucrose had risen to 14.67 per cent. Here was indicated a most important chemical change, in which not only the sucrose was enlarged, but over half of the grape sugar or glucose changed to cane sugar or sucrose. A third examination, September 16, 31 days afterwards, when the seed was ripe, hard, and dry, showed a still further enlargement of the sucrose to 15.95 per cent., and a still further absorption of the glucose, of which 0.65 per cent. was detected by analysis. Another examination, not long afterwards and just following a severe frost, showed little or no change, the sucrose had increased to 17 per cent. and the glucose to 1.00. These experimental results place the Early Amber almost on a par with the best Louisiana cane.

The departmental experiments included several other varieties of sorghum and other sugar plants. The Chinese cane was examined at the same times that the Early Amber, and gave the following results. When the seed-head was just out, there was 5.55 per cent. of glucose and but 1.85 per cent. of sucrose; when the seed was hard and dry, there were developed 1.35 per cent. of glucose and 13.90 of sucrose; after the frost, the glucose had enlarged to 1.85 and the sucrose had declined to 13.10. The White Liberian cane showed its maximum of sucrose 15.20 per cent., and its minimum of glucose 0.95 per cent., when its seeds were dry. The Honduras, before the seed-head was out, gave 5.13 per cent. of glucose and 1.20 per cent. of sucrose; when the seed was hardening, its glucose had fallen to 1.30 per cent. and its sucrose had risen to 15.10.

The Louisiana cane of 1879 gave a maximum of but 12.47 per cent. of sucrose; the growth of 1878 gave 16 per cent. The fact seems sufficiently evident that the sorghum as a sugar plant contains an amount of crystallizable sugar fully equal to the Louisiana cane.

SEED.

It was suggested that by steeping the seed in warm water for 24 to 48 hours it would become sprouted, and hence would grow more rapidly. But, on the other hand, it was urged that a dry season would kill the sprouted seed and the crop would be a failure. Nature porvides the most opportune moistening.

The weight of opinion was decidedly in favor of seed brought from the latitude of Saint Louis. Some cane-growers had sent their seed to Missouri and Kansas to have a crop grown and its seed returned. Among the decisive facts reported, Mr. Miller stated that his seed imported from Southern Indiana 11 years before had produced on its first sowing stalks from 12 to 15 feet high; but by planting the seeds of each crop its successor showed a declining height of cane until it grew but 7 or 8 feet high. Mr. Wylie had averaged, with seed brought from the South, 273 gallons per acre; the following year, using his own seed, he obtained but 223 gallons, a falling off of 50 gallons. The president of the convention had found, as a general thing, that the deterioration of seed was not very marked till the third year. The Southern seed did not excel so much in an earlier ripening of the crop as in its increased product, the excess, in some cases, amounting to one-third. The sentiment of the convention was expressed in the following resolution:

"*Resolved*, That Early Amber cane-seed, grown in the latitude of Saint Louis, is the best seed for Minnesota for two years."

The seed has a value of its own for consumption on the farm. It was pronounced excellent for feeding hogs, sheep, or poultry. The 5 or 6 tufts growing upon a hill of cane were estimated as equal in feeding value to three average ears of corn. A member of the convention pronounced it equal to oats. Another had found that the seed fed to sheep made the fleece look lively and polished.

PLANTING.

Plant just deep enough to secure moisture. Hence, earlier plantings should be shallower than late ones. There was some difference of opinion as to the arrangement of he hills. The president of the convention, Mr. Kenny, plants in rows 3½ feet each t way and uses 2 pounds of seed per acre or 6 or 7 seed to the hill; at the second hoeing he thins them out. Mr. Day marks the rows 3 feet each way. Seed should be planted not down in the trough of the marking furrow where a heavy rain is apt to wash it away, but on the edge. Mr. Wiley plants from 15 to 18 inches one way and 3 feet the other way, the rows running north and south, thus doubling the number of hills planted by Mr. Day. A tract of 4 acres sown broadcast was reported as producing at the rate of 450 gallons per acre.

Mr. Miller practiced stepping upon the seed as they were placed in the ground. Several planters present sanctioned this practice, urging that the close pressure of the soil around the seed enables it to germinate more rapidly. It was objected that stepping the seed caused the ground to bake, but it was replied that this was the case only with wet clay ground.

CULTIVATION OF THE CROP.

The leading point presented in the culture of cane is keeping it clear of weeds. This requires prompt action with the hoe, drag, and cultivator. A grain farmer suggested the use of Thomas's harrow, of 90 steel teeth, but the general sentiment was that the cane-plants were too tender for any such treatment. It should be thoroughly hoed until large enough to cultivate with the plow or cultivator.

TIME TO CUT THE CANE.

Mr. Whiting had found the best results from early cuttings, but admitted that in the later cuttings it was the extreme hot weather that had changed the sucrose to glucose. The president thought the proper time was when the seed is in the stiff dough, or from August 28 to September 1. It seems to improve for a few days, but afterwards it begins to decline in saccharine matter. The earlier the cutting after the seed has reached the dough stage the larger the product and the brighter and cleaner the sirup. The question of suckering was considerably debated, and facts both *pro* and *con* were alleged, but the convention expressed no collective opinion.

HARVESTING.

The question of stripping the leaves elicited considerable discussion. On the one hand it was urged that if the leaves were put through the mill with the stalk they would absorb a large portion of the juice. It was replied that this would not be the case with mills of sufficient power. Force enough should be applied to express the whole of the juice.

It was complained that cane-growers lost a great deal by purchasing cheap and poor machinery. One gentleman estimated the cost of stripping the leaves before cutting at $15 per acre. Some advocates of stripping were disposed to admit that it would not pay unless labor were plenty and cheap. The Commissioner of Agriculture stated that the department experiments showed little or no difference between stripped and unstripped cane, although the department mill was an indifferent one. Several urged that if the leaves were dry they would not in any way affect the quality of the sirup. The convention did not express any general opinion upon this point. It was considered of first importance that the tops be completely removed, as a single top sent through the mill would spoil a large amount of sirup.

The cane should be cut, some say, 6 or 8 inches from the ground, and others, at the first joint. The top should also be cut off from 18 inches to 2 feet; there is no sweetness in either the tops or the roots. Some planters laid the cane in windrows, and others were opposed to the practice as exposing the leaves if not the stalks to mildew. The storing of cane after cutting started discussion. Some insisted that it should be immediately placed under cover to avoid the evaporation of the sun's rays. Others piled in ridges 4 feet high, and covered the mass with marsh hay. To this it was objected that the lack of ventilation would spoil the cane. To obviate this difficulty some planters were in the habit of laying poles along the piles every 2 feet, in order to admit fresh air. Some would pile it as cane is sometimes piled in the field, crossing the hills in such a way as to secure ventilation and to shed the rain. Cane that had been kept in these different ways for several weeks were reported as having produced large and fine sirup products. One planter produced juice that ranged from 7 to 10, from cane that had been stripped and covered with leaves, while other cane of the same lot, that had been ground with leaves on, ranged as high as 12. Dr. Goesman, of Massachusetts, was quoted as saying that there was a gain of 3 per cent. by being allowed to lie with the leaves on. One planter had found such cane to test 11, while stripped cane tested only 10. The higher per cent., however, was by many attributed to the evaporation of the watery part of the sirup, leaving the saccharine matter in larger proportion to the residue. Others had not found the juice to be any sweeter after evaporation.

TRANSPORT OF CANE TO THE MILL.

Mr. Wiley thought it would pay every farmer to have his own mill. The price of the sirup in the market ranged from 35 to 50 cents per gallon. The mill owner will charge from 15 to 25 cents per gallon; if to this be added a charge, say of 10 cents per gallon, for hauling to a distant mill, it is easily seen that the grower gets but a small proportion for his labor. It cost the president $19.14 to haul the cane of 12 acres—part of it near the mill, and the remainder about a quarter of a mile away. It is better for the farmer to have the profit of manufacturing the cane as well as of raising it. In moving the cane from the field there was a strong expression in favor of bundling it. Some would decapitate it with a broad-ax, after binding. Some used a common dump-cart with an elongated box. The points kept in view, both in the transportation and in the storing of the cane, were protection from the weather, and such ventilation through the mass as would prevent mildew.

GRINDING.

The first step in the manufacture of sugar and sirup is the grinding or crushing of the cane to express the juice. Mr. Miller saw men at work with a very indifferent apparatus, which extracted but a small portion of the juice. On remonstrating with them he was told that if you extracted too much of the juice it soured the whole. This ignorant prejudice assumes what chemical analysis and intelligent experience has exploded—that only a portion of the juice is fit for evaporation. The almost universal expression of the convention was in favor of extracting the last possible portion of the juice. For this purpose the most powerful mills were considered as essential to the working of the crop. The president, Mr. Kenny, has a mill weighing 4,000 pounds, with rollers 16 inches long and 16 inches in diameter; with a 24-horse power engine it expresses 4,000 gallons of juice per day, getting from 65 to 70 per cent. of the juice in the stalk.

Mr. Keating had a small mill, expressing about 75 gallons per day, that worked very well, cutting every stalk at the joints and feeding 8 to 15 stalks at a time. Mr. Whitney says that small mills, like the Victor, if not too much crowded, will crush the cane perfectly dry. Clark and Utter's mill, manufactured at Dodge Center, with back gearing, was reported as a very efficient mechanism; its cost was $100. The general sentiment was that the milling machinery should be sufficiently powerful to obtain the largest practicable per cent. of juice in the stalk. It was estimated that Minnesota farmers had lost thousands upon thousands of dollars through the use of poor machinery. Mr. Whiting gave a humorous account of his efforts to construct a wooden mill, which amounted to nothing.

In regard to the method of feeding the mill, it was urged that the cane should be inserted evenly, and with the butt ends foremost. The supply should be regular and up to the normal capacity of the rollers. It is not desirable that it be full at one time and half full at another. There is a considerable art in properly feeding a mill. An incompetent feeder will clog it up, from time to time, by an irregular supply.

TREATMENT OF THE JUICE.

After a thorough extraction of the available juice in the cane, the next step is its evaporation and defecation. Heat is the great agent in the clarification of the juice. Hence Mr. Earle claimed that the most important element in the whole process of manufacture is a good furnace. He would select a hillside fronting the direction of the prevailing winds in September, so as to secure as great draught as possible; place the furnace on a level lower than the mill, with a fall of at least 10 feet. With a furnace in this position, properly constructed, he has had but little difficulty in throwing a flame 16 feet higher than any ordinary height of stack, using the bagasse as fuel. It can be done also with light wood, but not with heavy wood. The furnace must have a ventilating flue. Mr. Wylie had scared his horses at night by the bright flames coming out of his stack. The president, Mr. Kenny, suggested it was not just the thing to send the heat in flames 15 feet above the stack; all that can be utilized is that which operates under the evaporating pan. Under the instructions of Mr. Swartz he had reconstructed his arch so that instead of a great blaze at the top of the stack there was an intense heat under the pan.

Mr. Earle had arranged his pans on different levels so that the back pan was 7 inches higher than the other. Mr. Dickenson followed the directions of an expert in the construction of his furnace, but could not get the back part of the pan to boil till he had torn out the furnace and reconstructed it in accordance with his own ideas. He raised his stack from 15 feet to 28 feet and would prefer at least 30 feet. To control the draught he put in dampers. He adopted other contrivances for concentrating the heat under the pan. As cord-wood was too coarse, he hired a man to split it fine. Oak and maple were unfit, but basswood, poplar, and other light, free-burning kinds will just meet the demands. The more rapid and intense the heat under the pan, the more complete the evaporation and defecation of the juice. Mr. Miller, who had formerly shared Mr. Dickenson's prejudice in favor of light wood, saw a counter-demonstration in Mr. Swartz's factory. There heavy red oak and jack-oak sticks were made to produce an intense heat by mingling them with coal. Mr. Swartz's arch was 2 feet deep and 2½ feet wide. It is best not to cramp the arch, but make it wide enough for the embers to spread and present a broader heating surface.

There were differences of opinion in regard to smoke-stacks. The prevailing tendency to make the pipes too small was noted by several speakers. One member stated as a scientific principle that the cubic contents of the stack or chimney should be at least two-thirds of that between the grates and the fire. Mr. Miller thought Mr. Swartz's chimney a perfect pattern. It was 35 feet high, and from 2 to 3 feet in diameter. No flame came above the stack at night. The width of his own fire-place is about 30 inches, with which he is able to boil as fast as desirable with dry basswood and poplar.

Mr. Swartz does not break the scales off his pan, but lets them remain till they become loose of themselves; then they would be removed in the daily cleansing of the pans. He finds that the Liberian cane deposits a scale entirely different from the Early Amber. The sirup of the former does not turn nearly as early as that of the latter. Mr. Wylie gets rid of them by burning a forkful of straw under the pan when it is perfectly dry and clean. Then under the quick flame the scales will blister and fall off.

Mr. Wylie for five years had used the "Cook" pans. A neighbor, Mr. Stubbs, had made a new one, that is patentable, costing but $35, while Cook's cost $90. It is from 14 to 16 feet long, and has two partitions in it. It easily makes 100 gallons a day, a result requiring hard labor with Cook's pans. One man, with two of Stubbs's pans, can easily make 200 gallons a day, and read the newspapers besides. This opinion, however, was far from unanimous. A member had used Stubbs's pan for two years, but was dissatisfied with its results. It employs the principle used in the Faribault refinery in the collection of the skimmings. Mr. Wylie described the "Stubbs" pan with the aid of a diagram; sides 14 inches high, 36 inches broad on top, 16 feet long. It is arranged with a center foundation so that it cannot burn; the heat is cut off with a damper. In producing 2,725 gallons of sirup, Mr Wylie had used 4½ cords of wood, at $1.25 per cord. The center arch is within 5 feet of the front of the pan. It is set level. Five years ago the Cook pan only was used in Medina, Minn., now not one is in use there, while twenty Stubbs pans are used. It is better than the Blymyre pan because it skims itself, and there is no clinging of the skim to the sides.

Mr. Miller had invented an attachment to the Cook pan, which overcomes all the difficulties heretofore complained of. Cook's pan, with this attachment, runs the juice in and the sirup out without change. It does not discolor the sirup by reboiling. Hence the sirups made in Cook's pans are clearer, and freer from muddiness, than other sirups. Mr. Wylie denied that sirups boiled in the Stubbs pan were at all muddy, and showed a very fair specimen. The merits of different pans were presented at some length by different speakers.

C.

ILLUSTRATIONS OF SUGAR MACHINERY.

The following illustrations of the mechanical processes of sugar-making in different parts of the world are not intended to advertise the business of the manufacturers who have so kindly furnished cuts of their machinery for this report, but to present to farmers desiring to engage in sugar-production type specimens of approved methods of working up the cane. There are other manufacturers whose models do not appear in this report, who, doubtless, are able to furnish machinery at reasonable prices. The purpose of these illustrations is to present to sugar-growers some of the facilities which the market affords for their enterprise and to put them upon inquiry as to where they can obtain the best machinery and at the lowest prices.

Plate V shows the Victor cane mill, an apparatus in very common use. It is constructed with vertical rollers on a plan suited to horse-power, or with horizontal rollers for water or steam power. The horizontal mills are fitted with extra gearing, are necessarily heavier and require greater motive power to accomplish the same result. Plate V shows the vertical mill, of which seven sizes are on the market; the smallest is a 1-horse power mill, running 40 gallons of juice per hour, and weighing 395 pounds, at a cost of $48; the largest is a 4-horse power machine, 1,900 pounds weight, running 170 gallons per hour, and costing $230.

Plate VI shows the vertical Victor mill, with the horse-power operating in a lower story. The advantages claimed for this arrangement are, 1, the mill is more steady;

2, horses and cane do not interfere with each other; 3, the bagasse is more easily removed; 4, the juice flows down into the evaporator. For five different sizes the prices are $90, $105, $140, $155, $240.

Plate VII represents a horizontal Victor mill adapted to steam or water power, of which three sizes are in the market, viz, No. 1, weighing 2,200 pounds, and valued at $250; No. 2, 3,500 pounds, $350; No. 3, 4,000 pounds, $450.

Plate VIII, Fig. 1, represents a portable "Cook" evaporator, of which three sizes are for sale. These pans are 44 inches wide and from 6 to 9 feet in length, ranging from 40 to 90 gallons per day. When the pans are of galvanized iron, the prices are, respectively, $65, $75, and $85. With copper pans the prices are from $55 to $70 higher. Each contains a portable furnace. The whole can be lifted into a wagon by two men and transported from field to field with a light Victor mill, and thus save the transportation of the cane.

Plate VIII, Fig. 2, represents a "Cook" stationary evaporator, of which there are seven sizes, adapted to corresponding sizes of the Victor mills. They are bedded upon brick or stone arches, and are 44 inches wide, ranging in length from 6 to 15 feet. Their capacity is from 40 to 180 gallons per day, and their price from $30 to $90 for galvanized-iron pans, and from $80 to $210 for copper pans. Furnace fronts and doors cost from $5.50 to $8; grates, from $4 to $8.

Plate IX represents still larger sizes of these pans.

Plate X represents a complete sugar factory, the size and cost of which must necessarily vary with the number of acres of sugar-cane to be worked up. A is the juice-tank; the juice, after running from the crushing-mill into a tank on a lower level, is pumped up to the juice-tank in the upper portion of the building. B is the defecator for the elimination of crude impurities. C C are settling tanks; D, supply tank from which the evaporator is fed; E, a Cook evaporator; F, supply-tank for the strike-pan; G, strike-pan, in which the semi-sirup is reduced to the proper consistency for sugar; H H, receptacles for scum; I, truck for carrying the sirup to the sugar room; J, the sugar-room, with cooling-boxes, barrels, &c.; here an even temperature is kept up to assist granulation; here, also, the sugar is drained and stored.

Plate XI represents a steam plant, or steam train, consisting of a duplex mill for grinding the cane. It has two sets of housing, and each set two rollers. Each stand of housing and rollers is placed 6 or 8 feet from centers, and the intermediate space occupied by an endless carrying-frame traveling in the same direction as the rotation of the wheels, and at the same speed. The cane is fed to one set of rolls, called the roughing-rolls, which slit and crush it. It is then received by the carrying-frame of wooden slats and carried to the other set of rolls. It is moistened, on its way, by a spray of water thrown by a steam jet. This saturates and fluxes the sucrose, not yet extracted, which is then obtained. This residuum, though diluted with water, is the richest of the whole. This mill, when properly fed, will grind from 5 to 6 tons of cane in twenty-four hours.

Plate XII is a vertical view of the last.

Plate XIII is a defecating tank 8 feet long, 5 feet wide, and 2 feet deep. Over the bottom is spread a manifold of steam pipe, and contains a strainer through which the juice, perfectly clear, can be drawn off. The tank may be cleansed with pure water for a fresh filling. Each tank-full can be handled in thirty minutes. Two of these tanks are connected with the mill, and are ample for defecating 600 gallons per hour.

Plate XIV represents an evaporator 6 feet in diameter and 4 feet deep. Each is furnished with coils of steam-pipe 125 feet long, and a diaphragm directing the currents of evolution over the steam-coils up the outside and down the middle axis. In the center of the pan is an adjustable, funnel-shaped skimmer, which may be raised or lowered, so as to be on a level with the surface of the boiling juice. It catches all the scum gathered by the currents and delivers it through a pipe penetrating the bottom, outside of the evaporator. Two evaporators will reduce 600 gallons of defecated juice to one-half the volume in an hour and a half.

Plate XV represents the concentrator, which differs from the evaporator by having a closed top and a water-jet condenser, producing a vacuum. In this vacuum 600 gallons of evaporated juice are reduced to 200, or only one-sixth the volume that entered the evaporator. This reduced liquid is called semi-sirup, and can be stored in tanks or shipped in barrels to a refinery, or reduced to a dense sirup in a vacuum-pan constructed very much on the same plan as the concentrator.

A complete sugar-mill, embracing the above apparatus, with engines, boilers, centrifugal dryer, tubs, tanks, and all other necessary appliances for making sirup and sugar, will cost about $10,000.

Plate XVI represents a very heavy crushing mill. The smallest size of this series of mills has rollers 12 inches in diameter and 20 inches long, expressing from good ripe cane about 150 gallons of juice per hour. Larger sizes do a proportionately larger share of work.

Plate XVII is an "exhaust steam clarifier." Heat is applied to the juice; the albumen is coagulated and the acid neutralized by milk of lime, which also renders insoluble sundry soluble impurities and precipitates them. But as an excess of lime attacks the sugar in the juice it is of special importance that its quantity be regulated. In this clarifier this is done by means of a vessel graduated by inches, each inch corresponding to 4½ cubic inches of milk of lime. The total quantity of the lime ranges from 0.01 to 0.03 per cent. of the total weight of the juice. When the proper temperature has been acquired, the scum rises to the top and begins to break and show bulbs. The proper point of defecation is then considered to have been reached, and the clarified sirup is drawn off by means of a double cock in the bottom of the defecator. The scum and precipitates are discharged through another channel.

Plate XVIII is a "direct steam evaporator," which receives the clarified juice from the steam clarifier shown in Plate XVII. The juice is boiled by means of a coiled steam pipe. The resulting scum boils over into a trough around the upper edge of the evaporator and is itself subjected to defecation afterwards.

Plate XIX represents a "steam train" of three clarifiers and one evaporator, represented in Plates XVII and XVIII. This steam train requires but few men to work it and is very cleanly in its action. It dispenses with pumps and ladles. The sirup is fully prepared for the vacuum-pan.

Plate XX represents a vacuum-pan. This pan can be placed upon framing or walls built up in the house, but it is considered preferable to support it upon iron columns as in the plate and independent of the building. The elevation should be sufficient to admit of discharging the "strike" into the "centrifugal mixer." The plate shows a vacuum-pan arranged to work on the "wet" system; that is, in combination with a water-pump. The sirup is boiled at a very low temperature, producing a larger quantity and a better quality of crystallized sugar, yet the boiling is so rapid that the sugar does not get time to become inverted. Heat is applied to the sirup by means of a coil of copper pipe filled with steam, which, on being condensed, is conducted back to the boiler.

Plate XXI represents a combination styled "Multiple effect." It embraces a direct fire evaporator for the first juice, working under a vacuum in connection with a strike pan with the combined water and vacuum pump, also the mixer and centrifugal machine. This machinery is especially designed for making sugar from sorghum and cornstalks. The process consists in boiling the juice in a tubular or cylindrical boiler very similar to a steam-boiler, the fuel being only the bagasse. The vapor is conducted by pipes to the valves in the vacuum-pan and admitted to the copper coil which serves as a surface condenser. A vacuum-pump draws off the condensed liquid and the vapors. As the liquid thickens it is passed to the strike-pan where, by means of a higher vacuum, the boiling is perfected into crystal. It is then discharged into the mixer, where it is gently stirred to prevent "settling." It is then drawn through valves in the bottom of the mixer into the centrifugal, where the molasses is eliminated and the granulated sugar fitted for packing. The molasses is discharged into a tank and reboiled, after which it is passed into cans and allowed to granulate; finally, the molasses is eliminated, as in the first run. The only use of a steam-boiler in this process is to drive the cane-mill and the centrifugal, which will require a small engine. This feature is claimed as a special advantage in cutting down the expense of the process. As there will be no very heavy pressure there is no danger of explosion, and consequently the boiler may be made less expensive. This method of reducing *in vacuo* prevents caramelization, as the air is kept off and only a low heat employed. The prices of this apparatus vary with the results to be obtained.

Plate XXII represents a form of centrifugal machine called the "German style." It runs in elastic bearings and does not require to be set in masonry. Its manufacturers claim that it will purge from 1,000 to 1,500 pounds of sugar per hour. Price, $400, with $10 extra for boxing.

Plate XXIII represents a "Hanging centrifugal machine," especially adapted to certain classes of gummy sugars. It requires no specific skill in the operator. Price, without frames, $775; with frames, $955, or $900 each for two machines; boxing, $10 for each machine. It is larger than the German machine described in Plate XXII, and discharges the sugar through the bottom. It will purge from 2,000 to 4,000 pounds of sugar per hour.

Plate XXIV represents the latest improved centrifugal driven from below. It will purge from 2,500 to 5,000 pounds of sugar per hour. Price, with frames, $1,000; two machines, $950 each; a machine without frames, $850. The sugar is discharged through the bottom.

Plate XXV, Fig. 1, is a cheap home-made evaporator, which can be put together by any ingenious mechanic. It is constructed by putting wooden sides and ends upon a galvanized iron or copper bottom.

Plate XXV, Fig. 2, is a pan for cooling sirup sent by a correspondent. Its method is sufficiently clear from the diagram.

Plate XXVI represents a newly-invented "evaporator." It is available either for concentrating cane-juice to the density of sirup to be finished in the vacuum-pan or, if the vacuum pan is not used, directly up to the point of granulation of sugar. Th defecated juice is brought through a canal shown on the left of the picture and deposited *continuously* in the first table of the evaporator. When it has acquired a depth of two inches steam is introduced into the pipes and ebullition immediately commences and the impurities begin to rise. The latter flow outward to the sides and are held there by a constant outward current. They may be removed without any waste of the juice. The discharge of water resulting from condensation is regulated by a valve. The gate is then opened and the juice is passed to the second table where it is subjected to the same process, and then to the third table. By the time it is ready to pass from the third table it is reduced to a density varying from 18° to 32° B. It then passes to the strike-pan on the fourth level where it is brought up to the sugar point. It is then drawn, either in a continuous stream or by "strikes," into molds or hogsheads. Not less than 15 hogsheads or 30 moulds should be ready for the sirup. These should receive, each in its turn, about 2 inches depth of the liquid, and when the last has received its quota begin again at the head of the series. This method of filling gives the sugar time to crystallize and cool; it dispenses with tanks and with a second handling. It is claimed in behalf of this apparatus that its elimination of impurities at the commencement of the operation, the limited time in which the sugar is subjected to the heat, and the low temperature used, cause only a minimum of inversion of cane sugar into grape sugar. An apparatus producing a cubic yard of sugar per hour is 29 feet long by 7 feet wide. It will require about 4,000 bricks to construct the walls. These trains are of all sizes desirable, with capacities ranging from 100 gallons per day to 1,500 gallons per hour. Prices from $50 for two small pans to $3,000 for large trains complete.

Plate XXVII represents the Stubbs Evaporator. The first cut shows the pan with two compartments. The first occupies three-fourths of the pan; the second compartment the remaining fourth. The juice enters the first compartment near the smoke-stack in a regular stream, passing around the circle over the fire-box to cross-partitions, where it thickens to a semi-sirup. Being over the hottest part of the furnace, it raises to a light foam, which breaks to the lowest point where the cool juice enters, not only keeping back the green scum, but carrying all the scum off of thirty feet surface, where it is scraped off without loss of sweet. The semi-sirup is turned into the second compartment at intervals to be finished under full control of heat governed by dampers. When done, to be run off with scraper, letting semi-sirup follow. Boil rapidly with two inches juice in order to cleanse well.

The second engraving represents the furnace. Should be built of brick, with eight-inch wall fourteen inches above fire-grate; the balance seven inches. A sectional arch with one damper in center, hinged at the back end to swing to back wall; also damper across the mouth of left flue. The smoke-stack stands back as the cut indicates. The smoke-stack should be 16 feet high, 14 inches diameter.

Price of evaporators.

Galvanized iron:	
No. 20, 16 feet long by 40 inches wide	$50
No. 20, 12 feet long by 36 inches wide	40
Charcoal iron:	
No. 20, 16 feet long by 40 inches wide	40
No. 20, 12 feet long by 36 inches wide	35

Plate XXVIII represents the mill, evaporators, &c., on the grounds of the Department of Agriculture at Washington, where the experiments of the last two years were performed. A description will be found in the chemist's report.

SUGAR-MAKING AMONG THE HINDOOS.

In 1822 the English East India Company published an exhaustive report upon "the culture and manufacture of sugar in British India." In the appendix is printed an extract from "Dr. Buchanan's journey from Madras, through Mysore, Canara, and Malabar, in 1800." The following illustrations present the processes in use among Hindoo sugar producers at the beginning of the present century.

Plate XXIX represents a sugar-mill consisting of mortar, beam, lever, pestle, and regulator. The mortar is constructed of a tree trunk, and is about 10 feet long and 14 inches in diameter, and is sunk 8 feet in the ground, leaving but 2 feet above the surface. The upper end is hollowed into an inverted conical depression in which the cane is crushed by a pestle, the juice being delivered by a tube running from the lower part of the mortar. Around its edge is a groove which receives what juice may overflow and conducts it by a pipe into the main receptacle. The beam is a portion of a tree 16 feet long and 6 inches thick, cut below the forks. The angle is enlarged and rounded, so as to embrace the mouth of the mortar around which it revolves, supported by a flange. The forks are then drawn together. On this beam are seated the mill-feeder and the ox-driver. The lever holds the pestle in its place, being held at one end by an upright piece of timber, called the regulator, to which it is pinned, and at the other end by ropes. The revolution of the pestle upon the small cut cane expresses the juice; the bagasse is removed by hand. The shape of the lever and the cavity in which it receives the upper end of the pestle causes the latter to revolve on an oblique axis; the lower end of the pestle is conformed to the conical depression in the mortar so that the cane may be subjected to the closest pressure. It is scarcely necessary to repeat the observation of Dr. Buchanan, that the machine is badly contrived. The sugar-makers of the village have each his turn at the mill, which is run night and day till all the crops have been worked up. The mill grinds about 56 pots of juice, or 218 gallons, in 24 hours. The oxen are driven at a rapid gait, and require to be changed several times during the day and night.

Plates XXX and XXXI represent modified forms of the Indian sugar-mill. The principle of pressure is the same in all, being the revolution of a pestle on an oblique axis in the conical depression of the mortar. The modifications are shown with sufficient clearness in the plates.

Plate XXXII represents a set of sugar machinery in use at Burdwan, near Calcutta, in 1792, as described in the minutes of the Indian Board of Trade of that year. The mill consists of two small wooden grooved cylinders working in a horizontal plane and propelled by two men turning spokes connected with each cylinder. This apparatus seems to be very inefficient compared with what was employed on the West India sugar plantations, but it is cheap, and worked by cheap labor. Heavy iron cylinders brought from England at great expense were unable to compete with the native machinery on account of the greater cost of working. In the left rear of the sugar-mill is seen a furnace with earthen pots for the boiling of the juice. The furnace is shielded from the weather by a shed open at the sides. The juice is dipped from one pot to another till, in the judgment of the boiler, it is sufficiently condensed. In this state it is called *goor*, a word which has no equivalent in English. The English in Hindoostan confound goor, sirup, or molasses under the general name of jaggary.

The goor goes to the *myrah* or boiler, who purifies it by different processes. The general method is that of boiling. Sometimes the molasses is first drawn from the grain and the goor is then boiled with milk, or with milk and water. In other cases the goor is only boiled and purified. Milk, lime, and lye from plantain ashes are used to cleanse and granulate the sugar. When boiled sufficiently it is put into earthen pots and two sorts of aquatic weeds of a supposed alkaline quality are used to drain off the sirup as clay is by European refiners. Clay is also used in some parts of India. Sugar thus prepared is called *cheenee*. Variations from the above methods are noted as prevalent in different parts of the country.

STEWART'S PROCESS.

Plate XXXIII represents the necessary addition to the ordinary sorghum machinery if the process of Mr. F. L. Stewart, of Murraysville, Pa., be used in making sugar. The plate illustrates the mode of using his powder B. H is the heating-tank, D the defecating-tank, from which clear juice is passed from the heater H. A stout, well-hooped half-barrel or ten-gallon cask, C, stands alongside the defecating tank, the head of which is pierced with two holes, at opposite sides, one five-eighths inch and the other one and a quarter inches in diameter. F is a lacquered funnel, with a gum ring fitting around its neck; *r* a plug, with gum fittings to insert tightly in the throat P, and a piece of rubber tubing, R.

Plate I.

EARLY AMBER CANE.

(Grown upon the Department grounds during the season of 1879.

Plate II.

CHINESE SORGO CANE.

Synonym: Sumac Cane, Chinese Cane.

WHITE LIBERIAN CANE.

Synonym: GOOSE NECK, White Imphee.

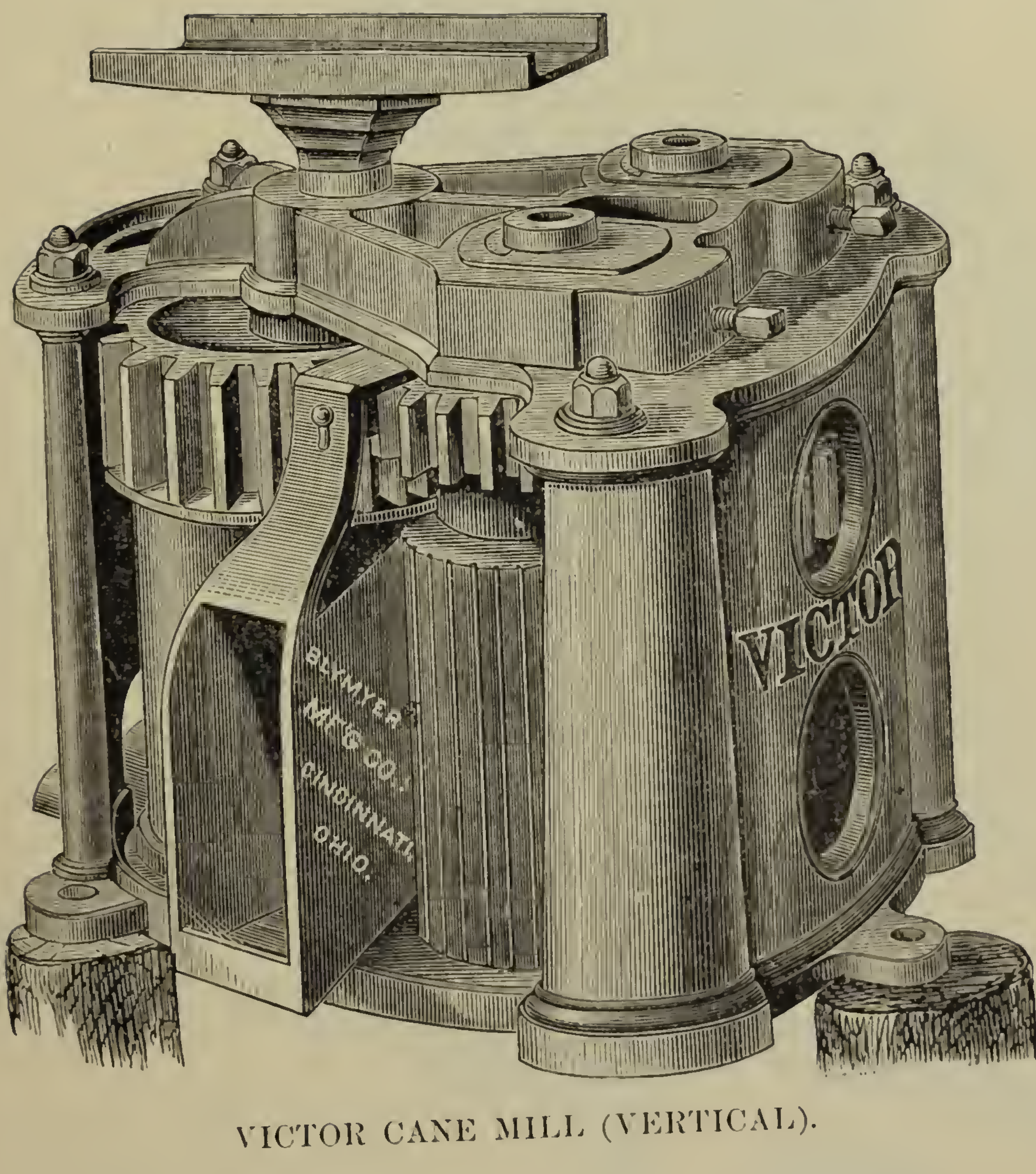
[Grown on the Department grounds during the season of 1879.]

HONDURAS CANE.

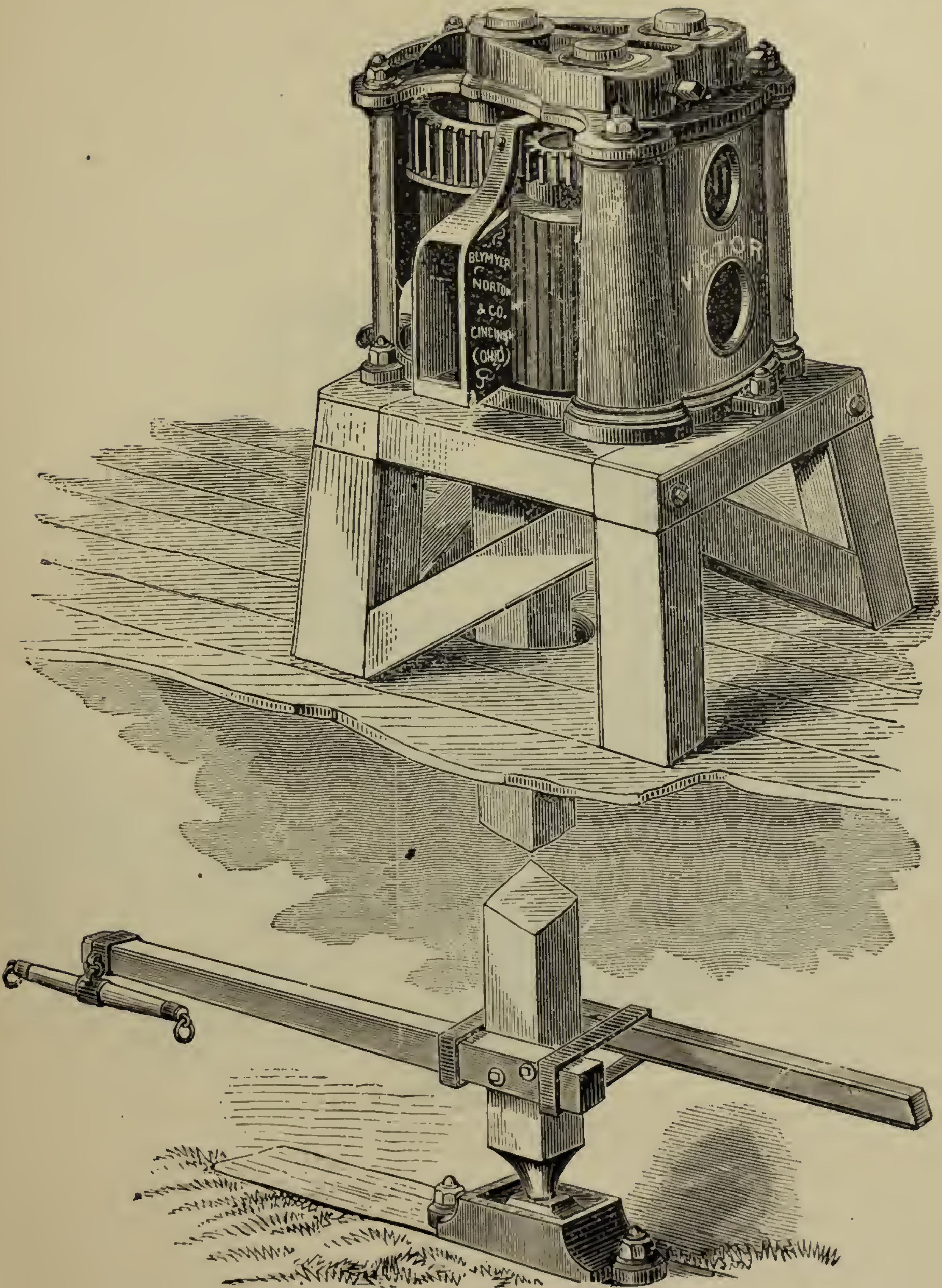
Synonyms: MASTODON, SPRANGLE-TOP, HONEY CANE.

[Grown on the Department grounds during the season of 1879.]

Plate V



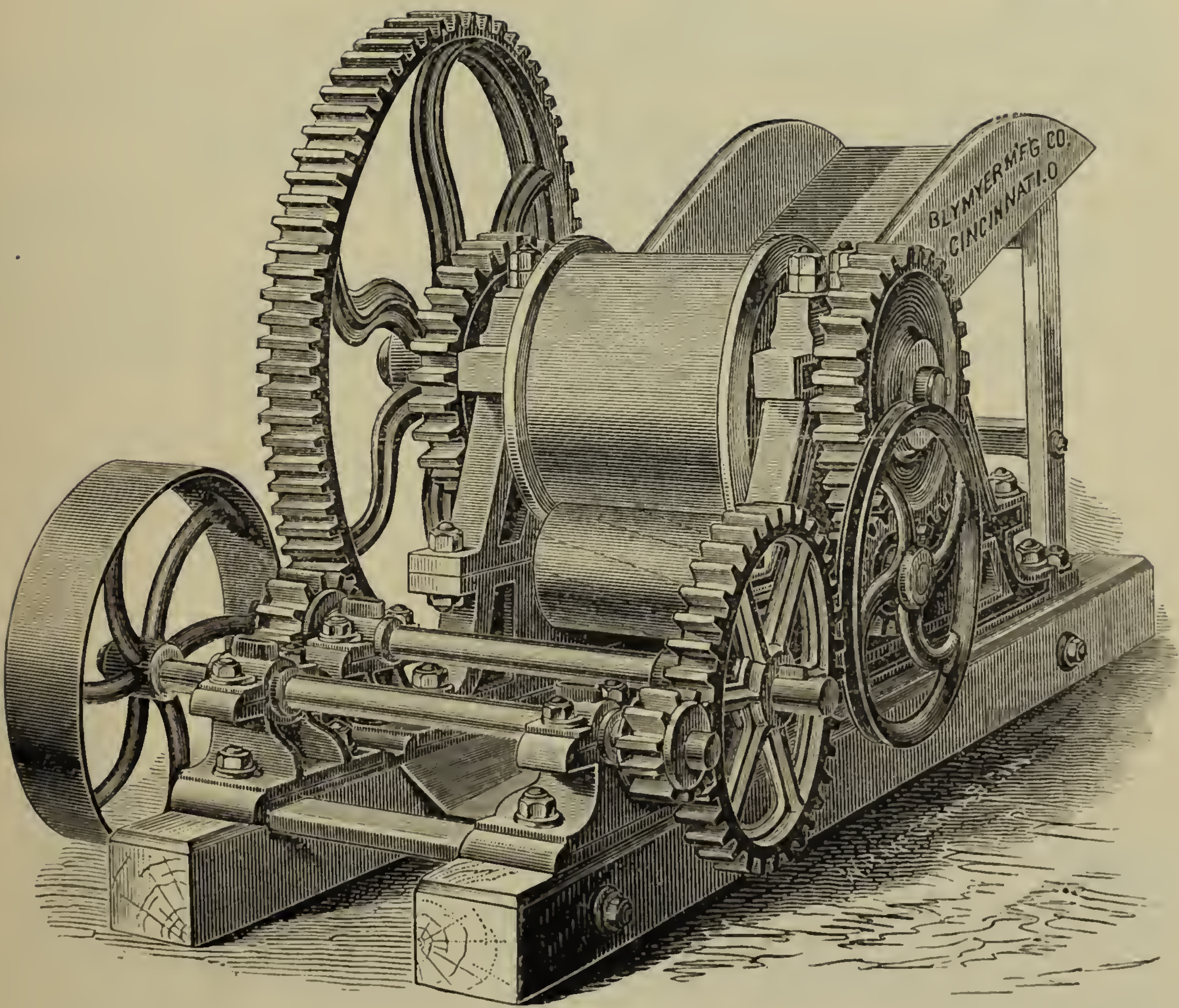
VICTOR CANE MILL (VERTICAL).



VERTICAL VICTOR MILL.

[With horse-power below.]

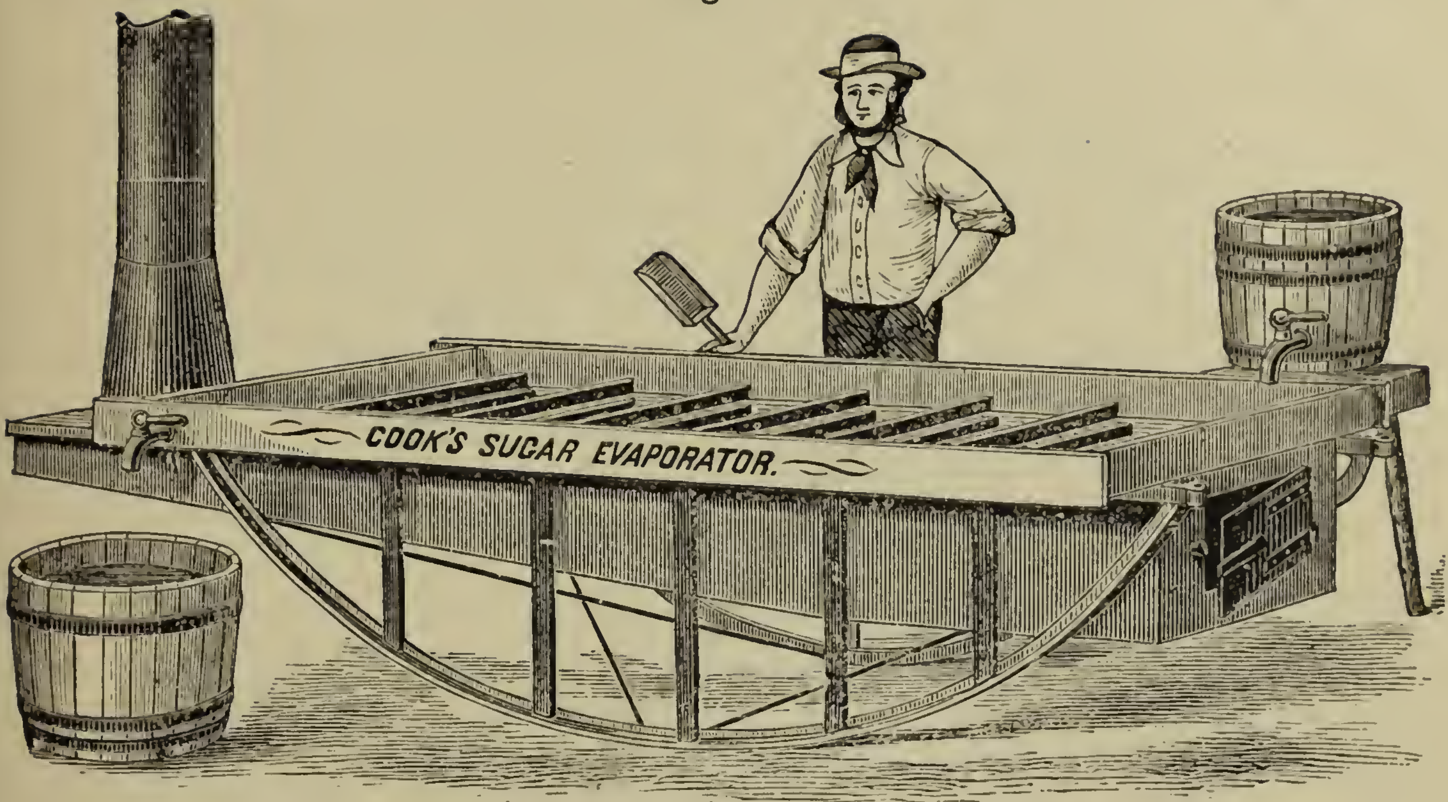
Plate VII



HORIZONTAL VICTOR MILL.

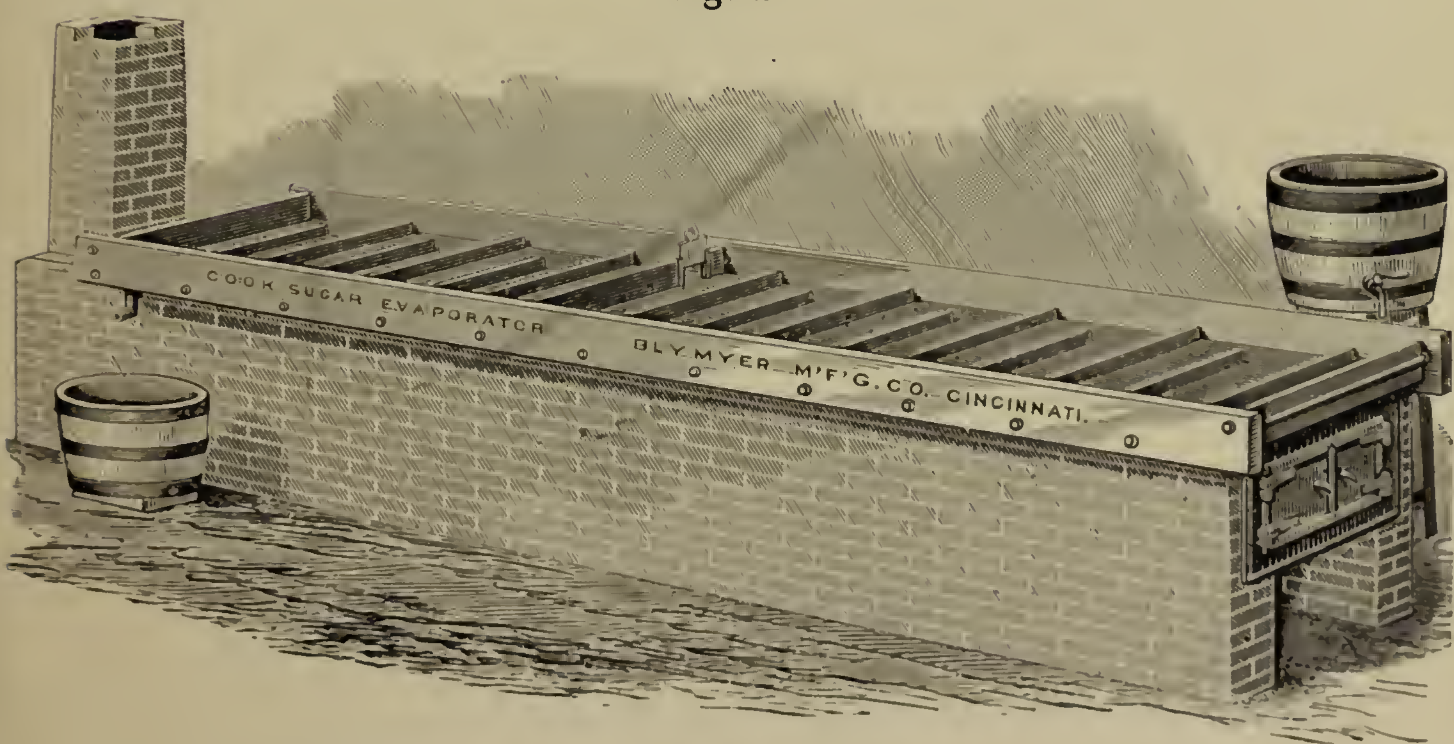
Plate VIII.

Fig. 1.



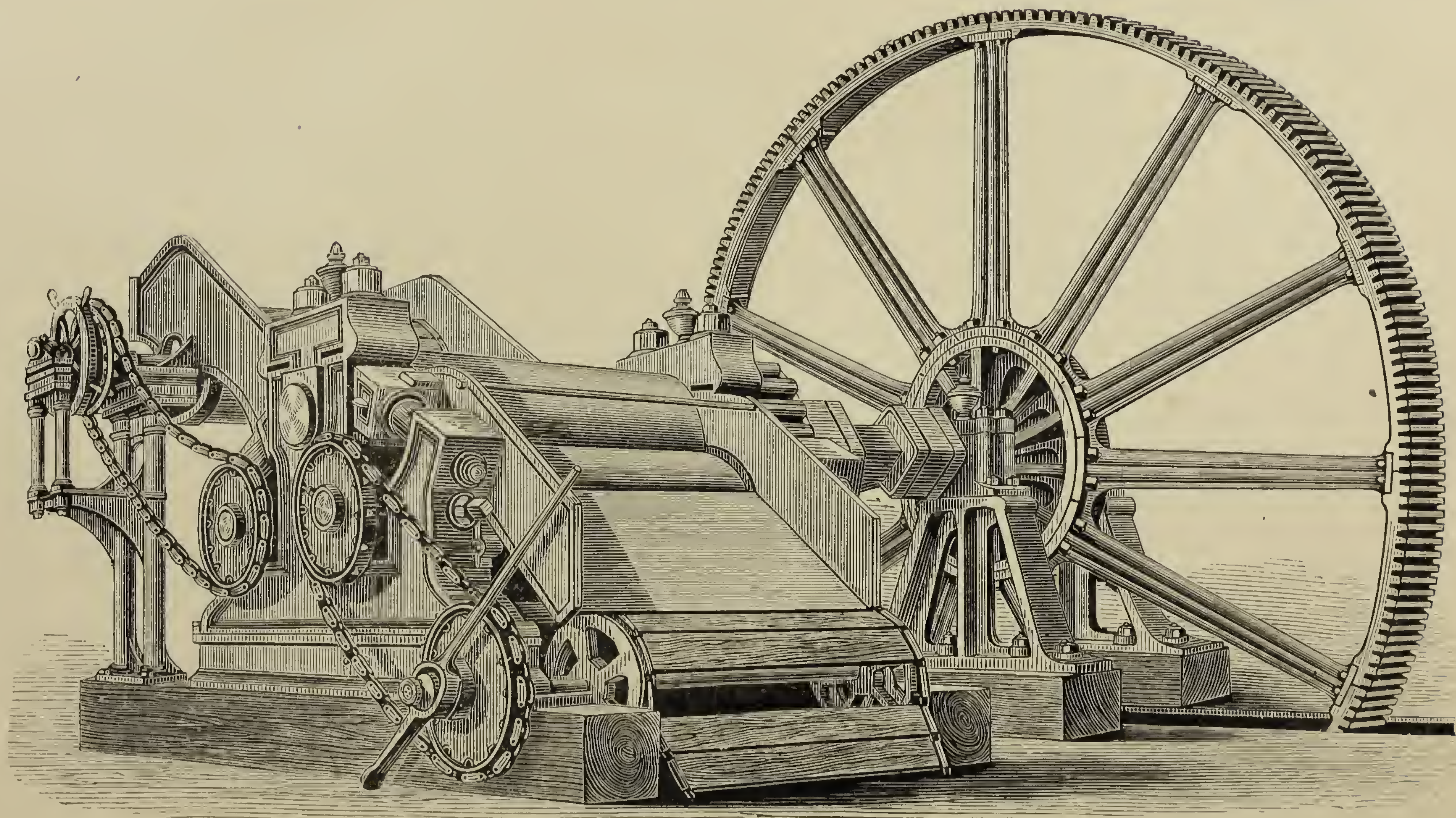
PORTABLE COOK EVAPORATOR.

Fig. 2.

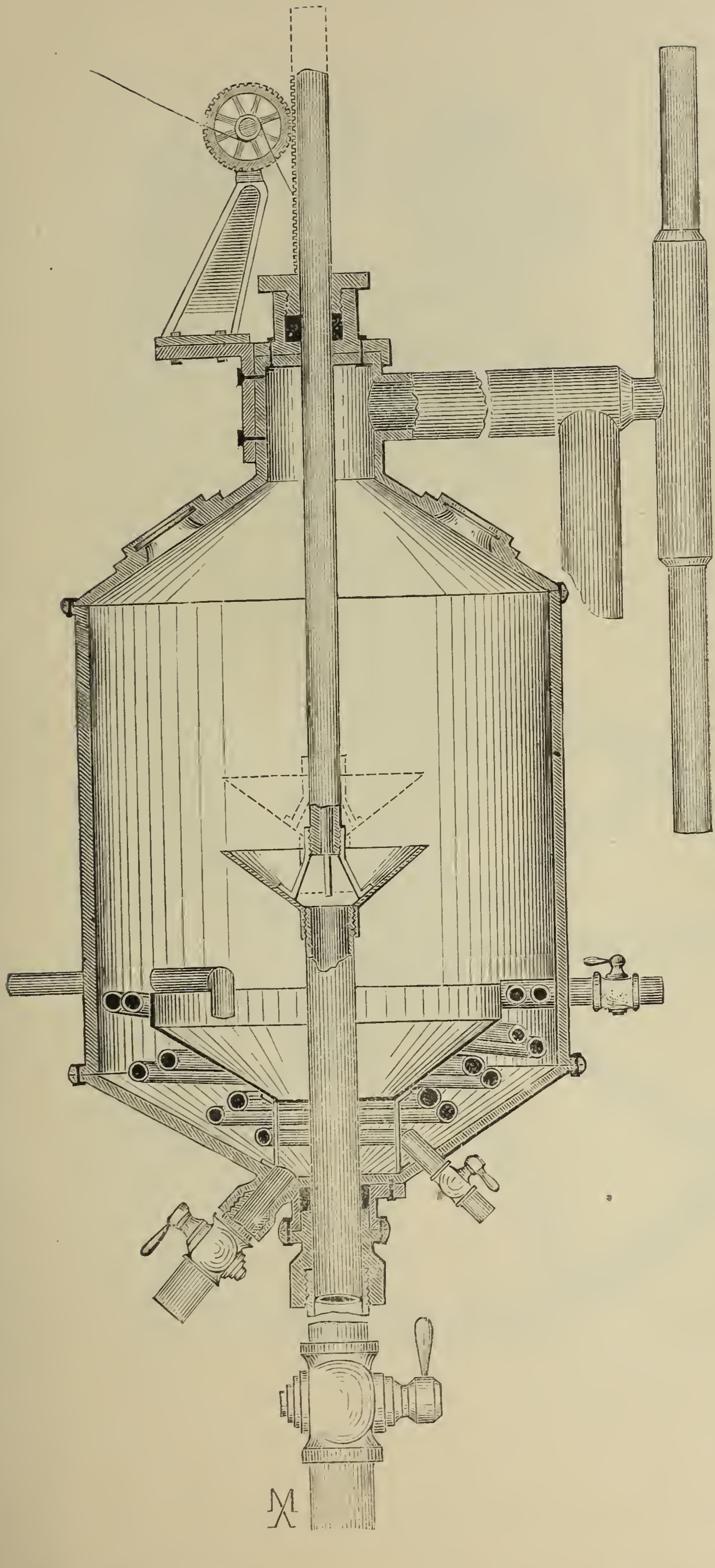


COOK STATIONARY EVAPORATOR.

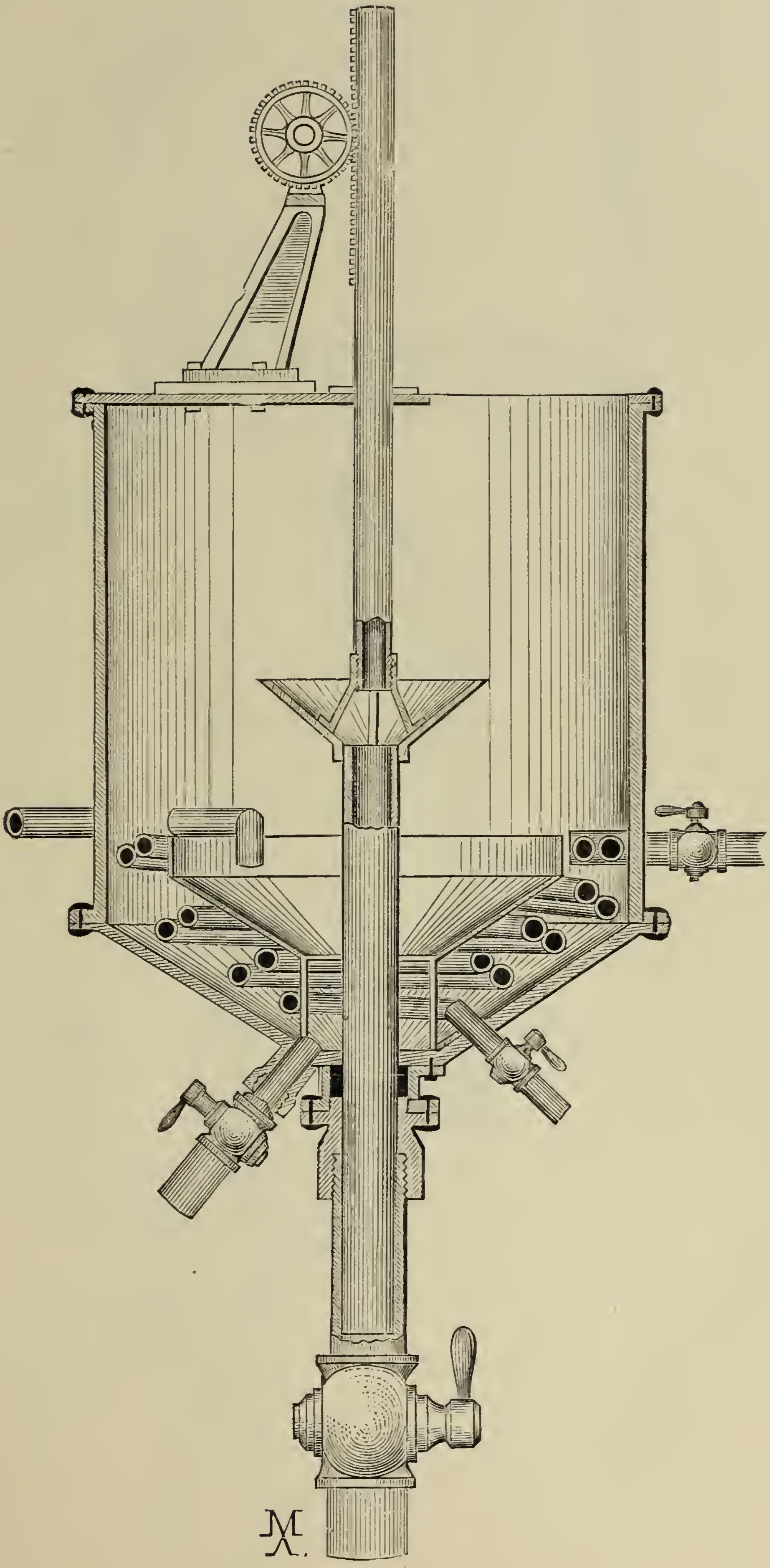
Plate XVI.



HEAVY CRUSHING MILL.

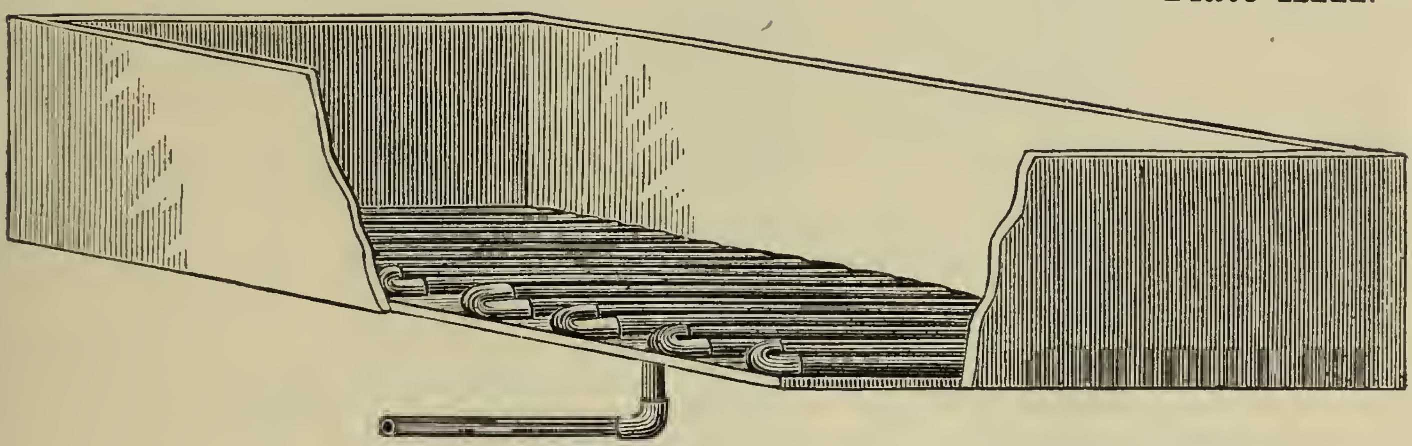


McDOWELL'S CONCENTRATOR.

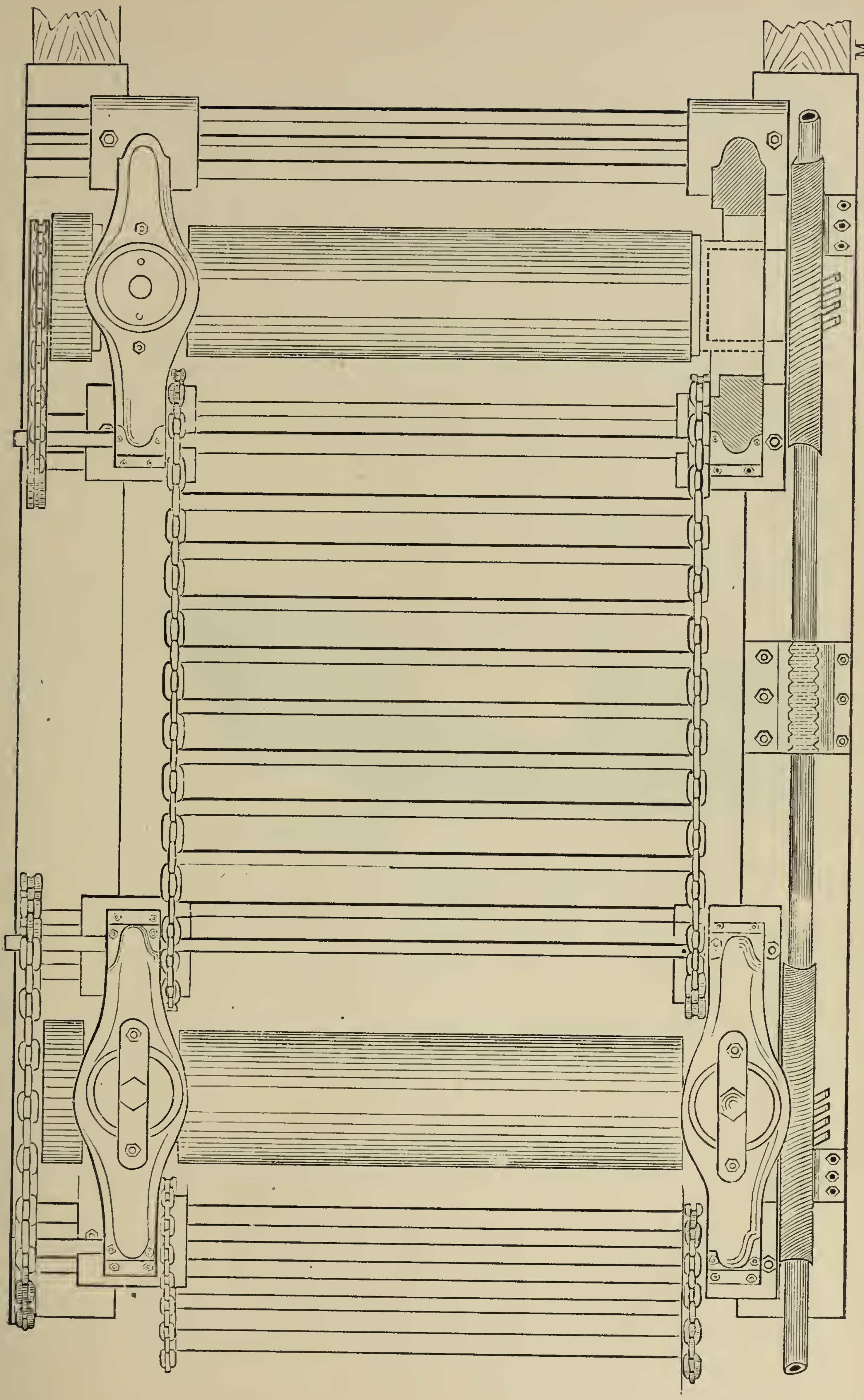


McDOWELL'S EVAPORATOR.

Plate XIII.



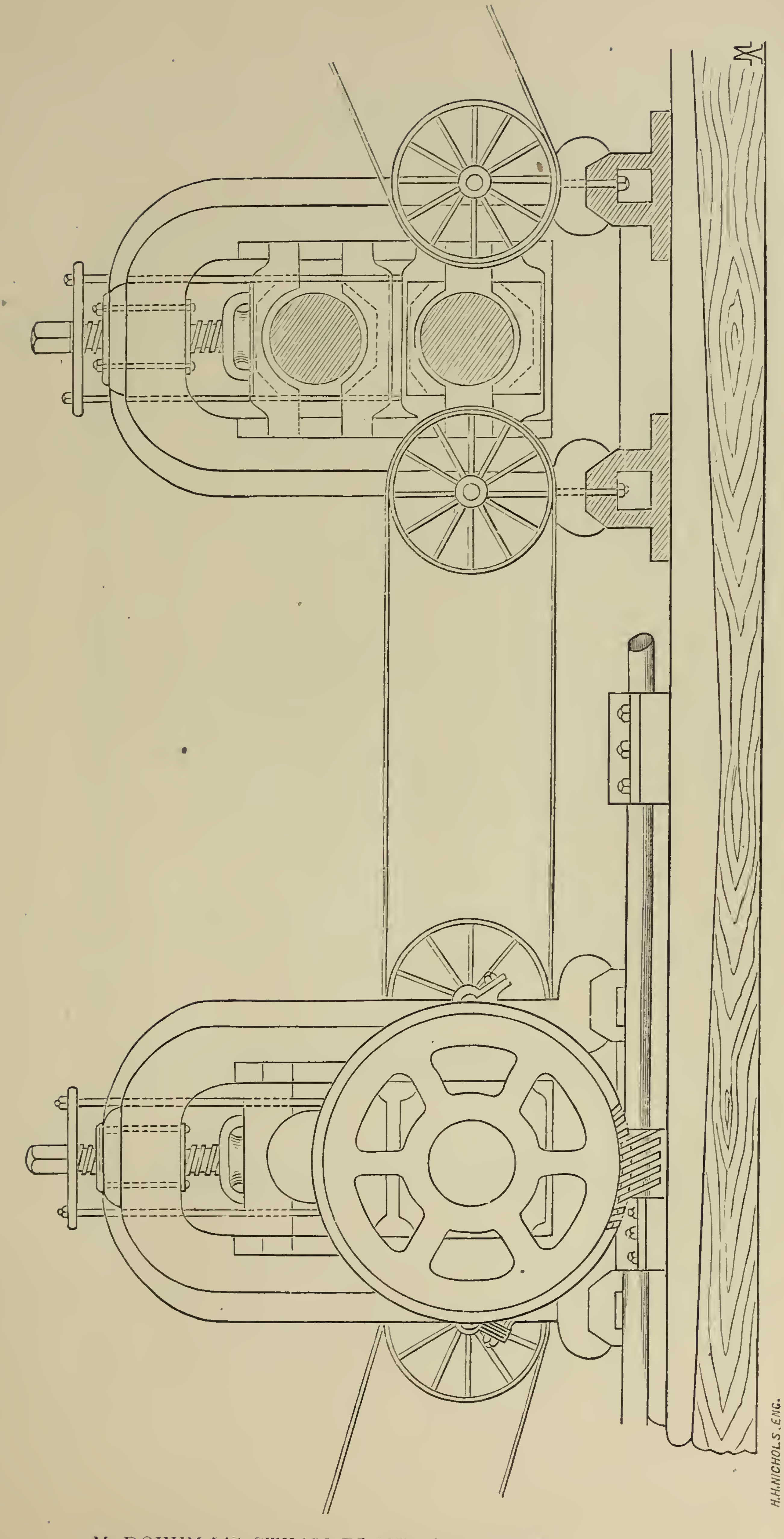
MCDOWELL'S DEFECATING TANK.



McDOWELL'S STEAM PLANT OR TRAIN.

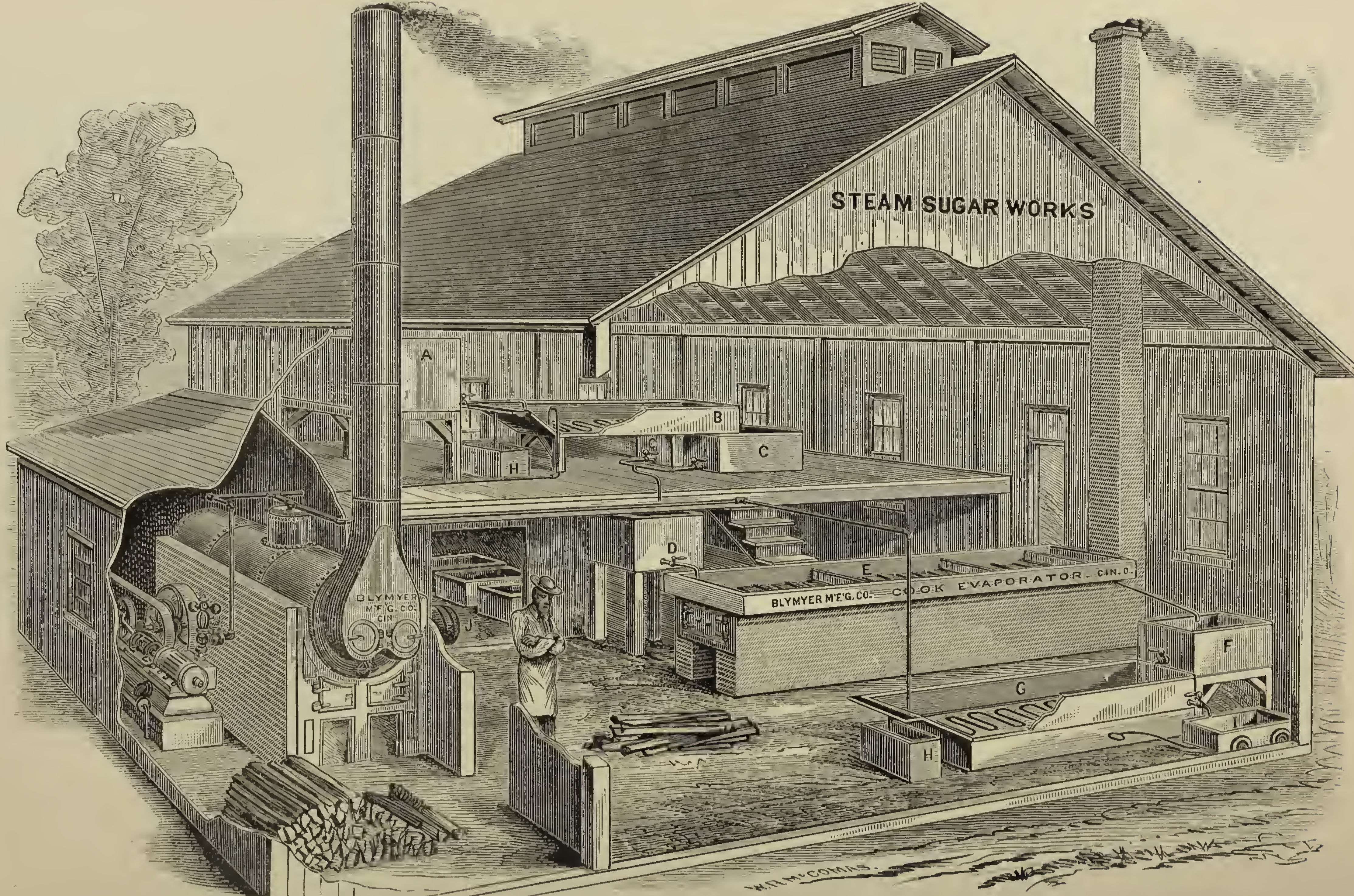
[Vertical view.]

Plate XI.



McDOWELL'S STEAM PLANT OR TRAIN.

Plate X.

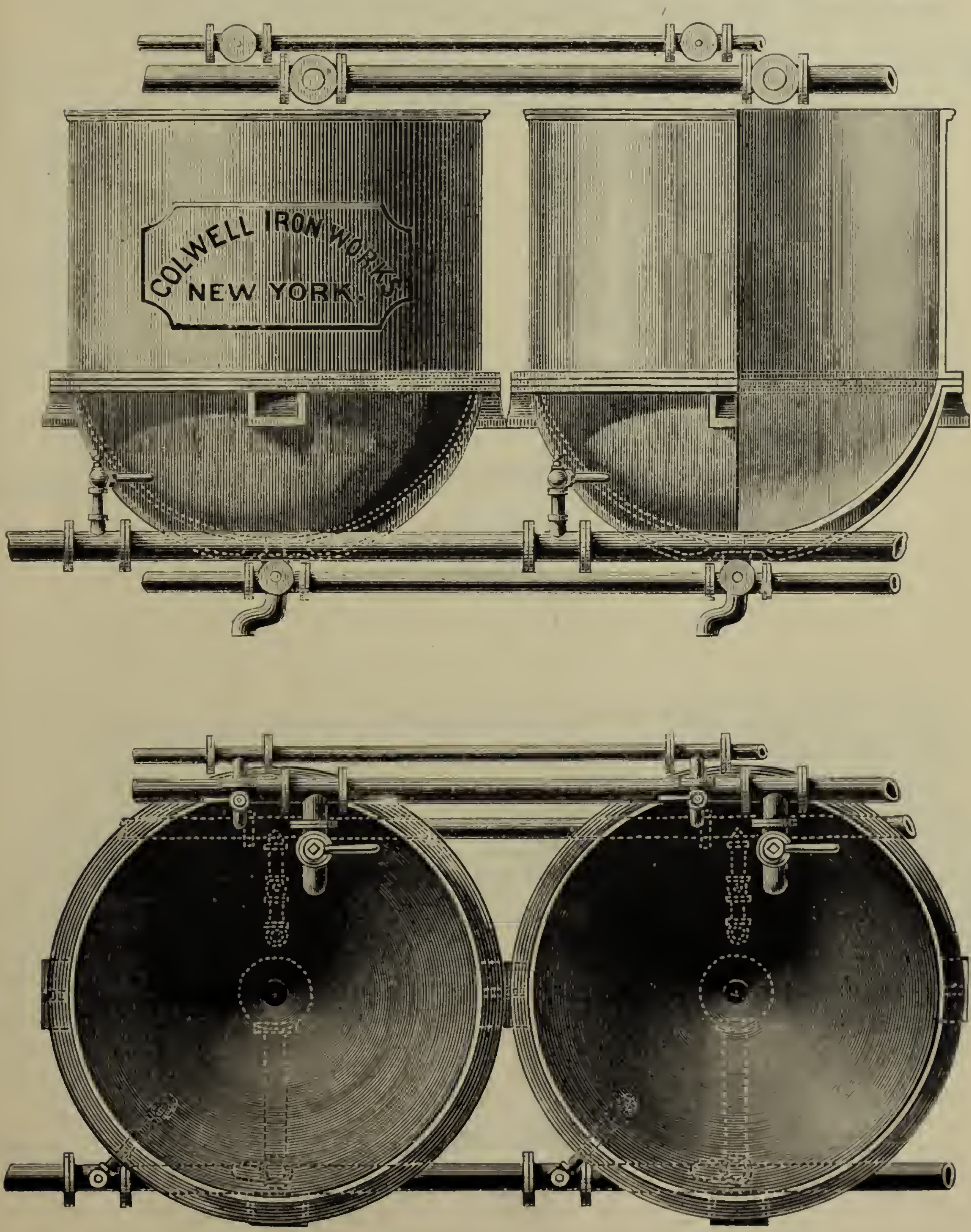


COMPLETE SUGAR MILL.

Plate IX

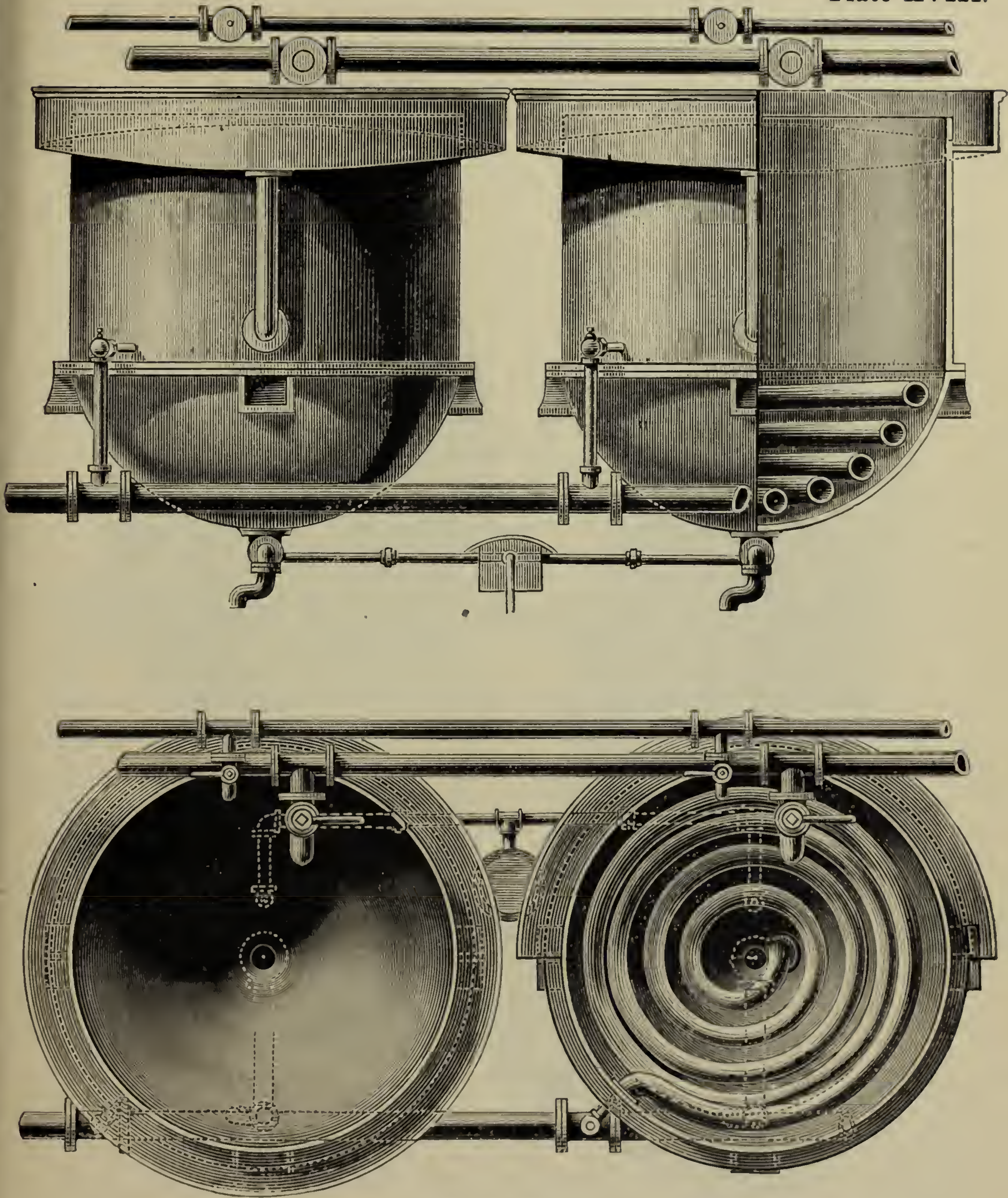
LARGE STATIONARY COOK EVAPORATOR.

Plate XVII.



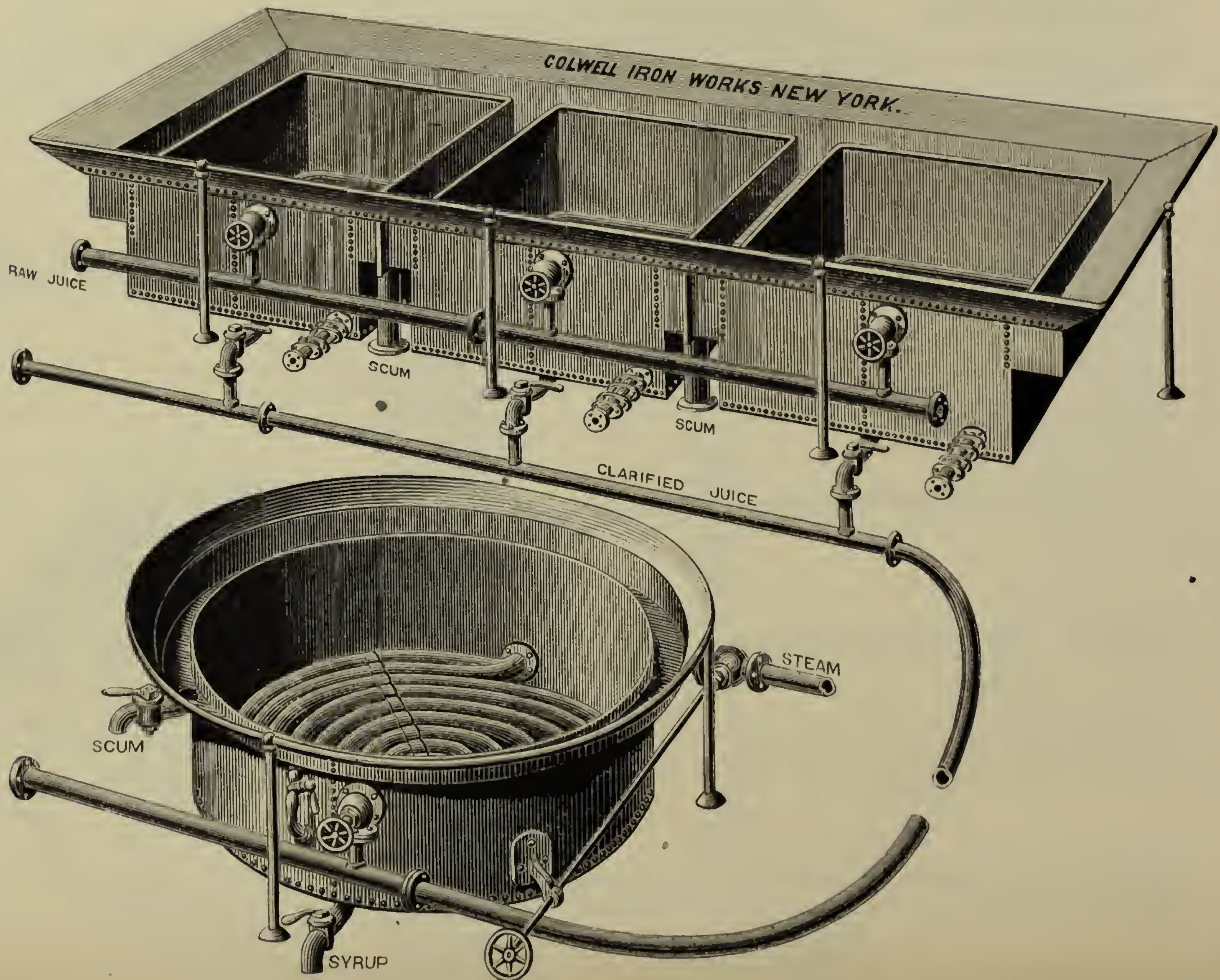
EXHAUST STEAM CLAMPER.

Plate XVIII.

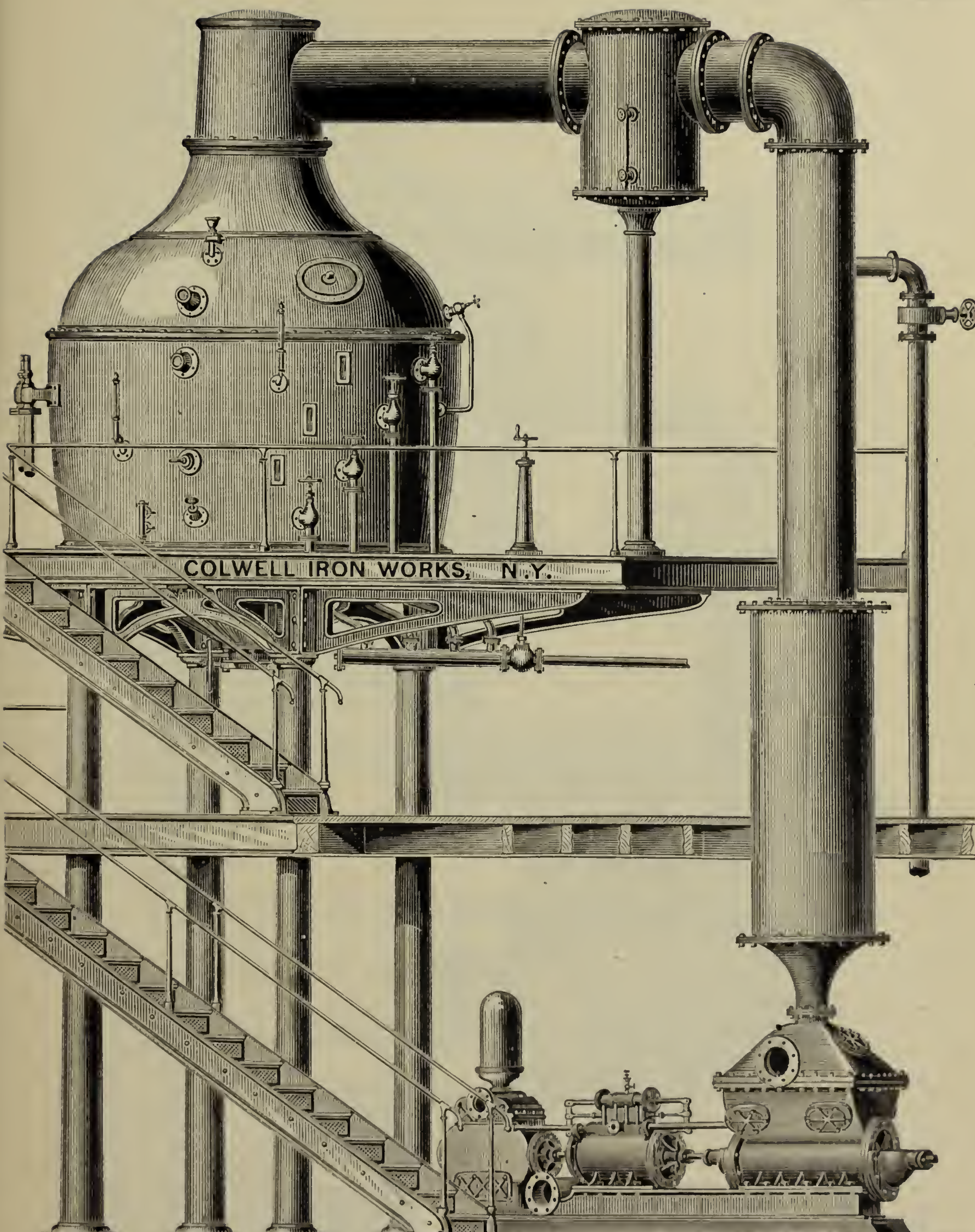


DIRECT STEAM EVAPORATOR.

Plate XIX.

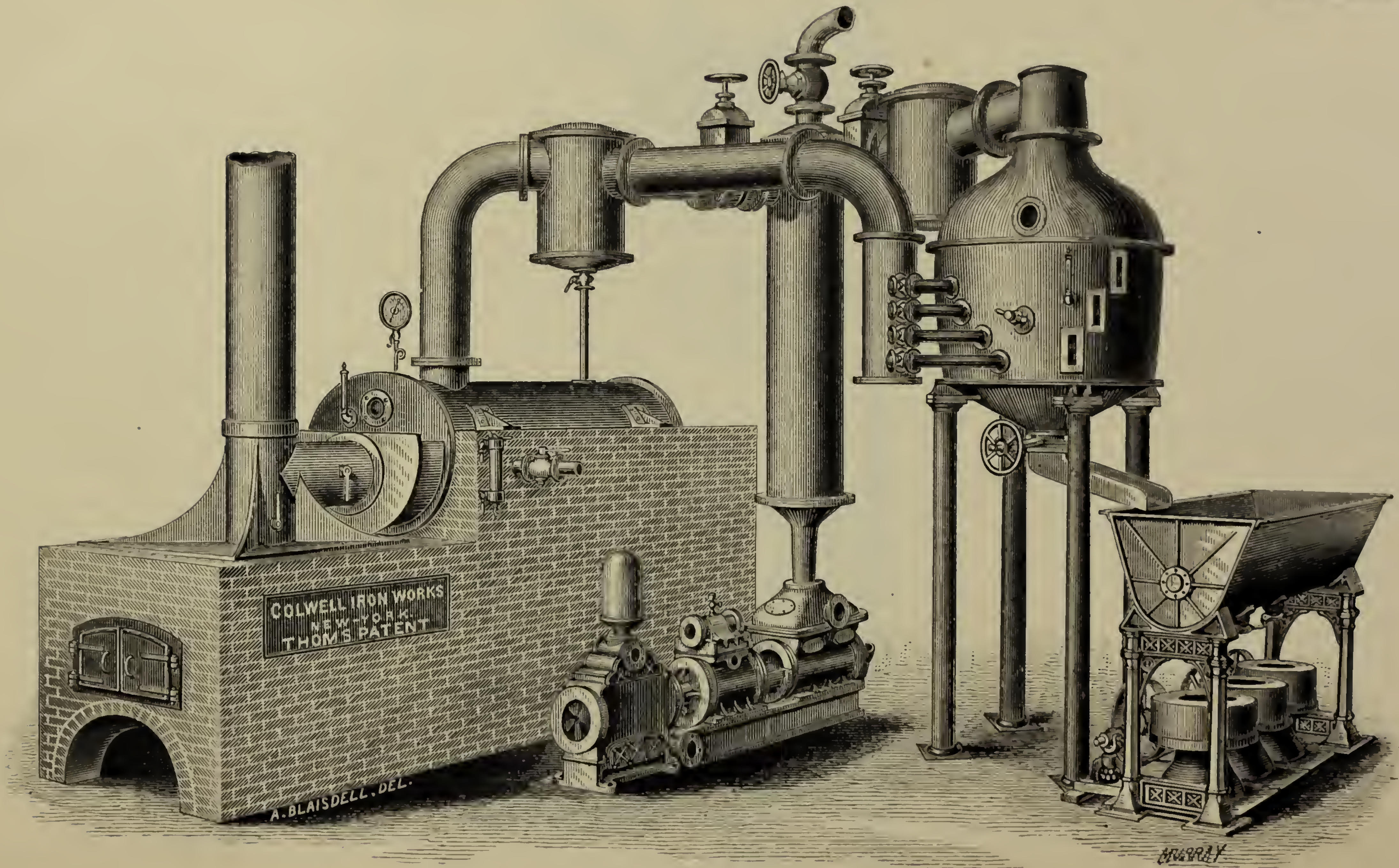


STEAM TRAIN.



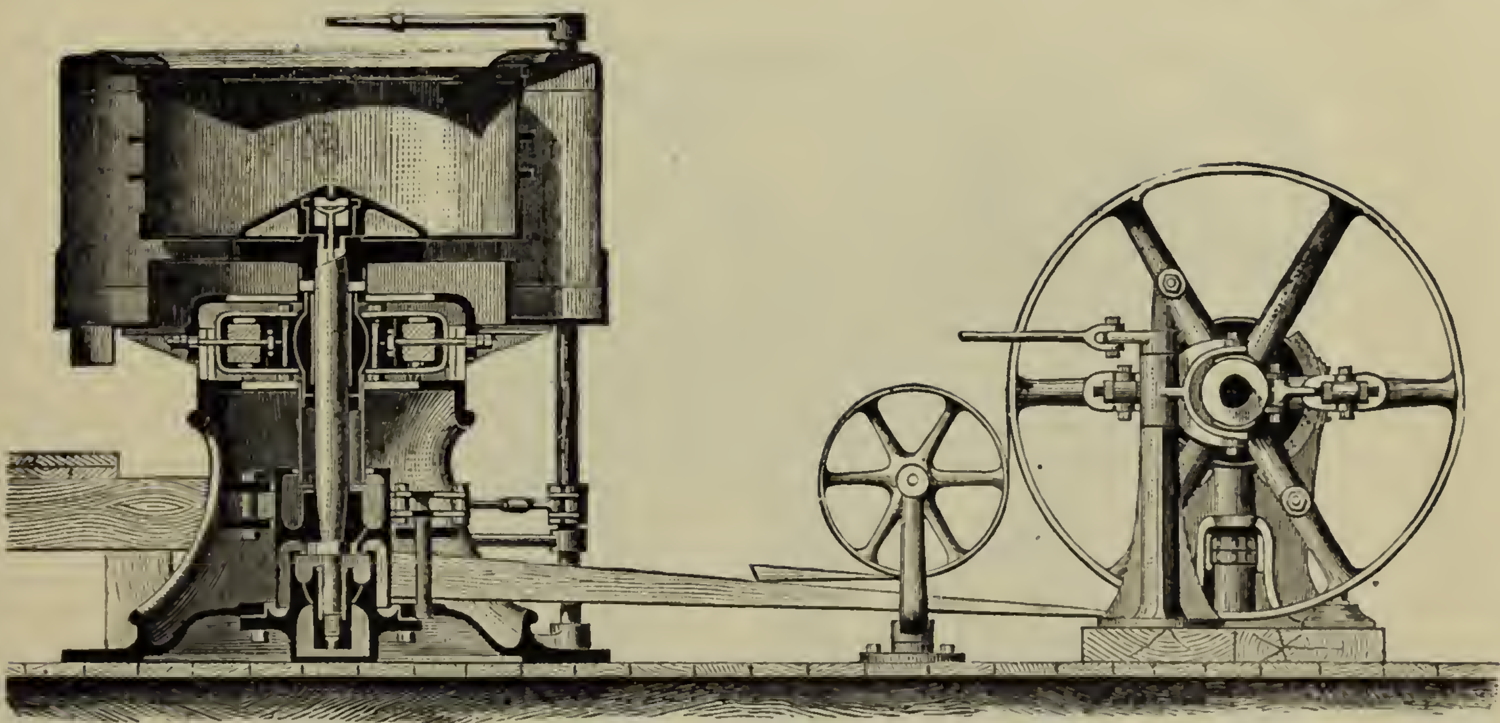
VACUUM PAN.

Plate XXI.



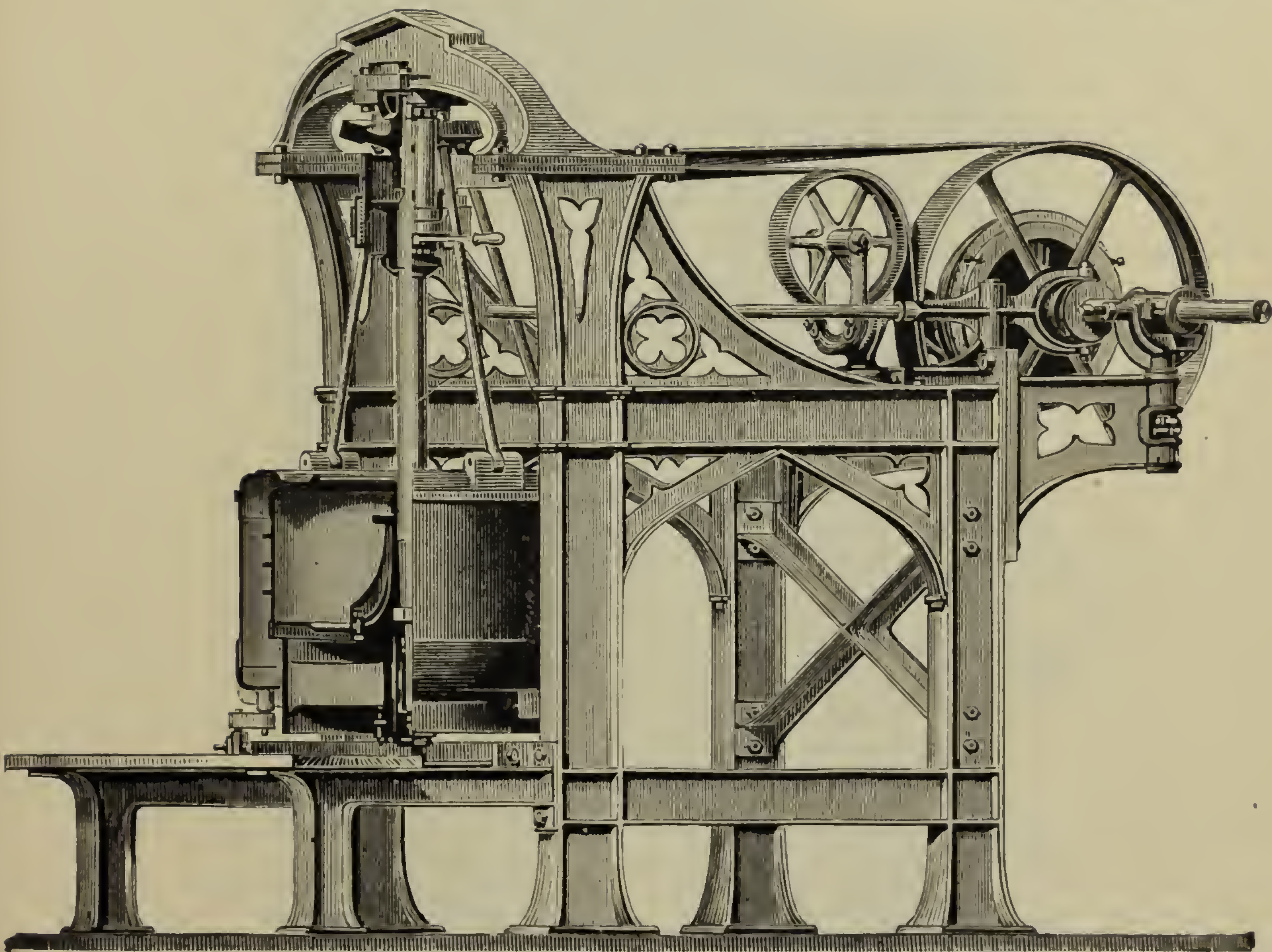
MULTIPLE EFFECT.

Plate XXII.



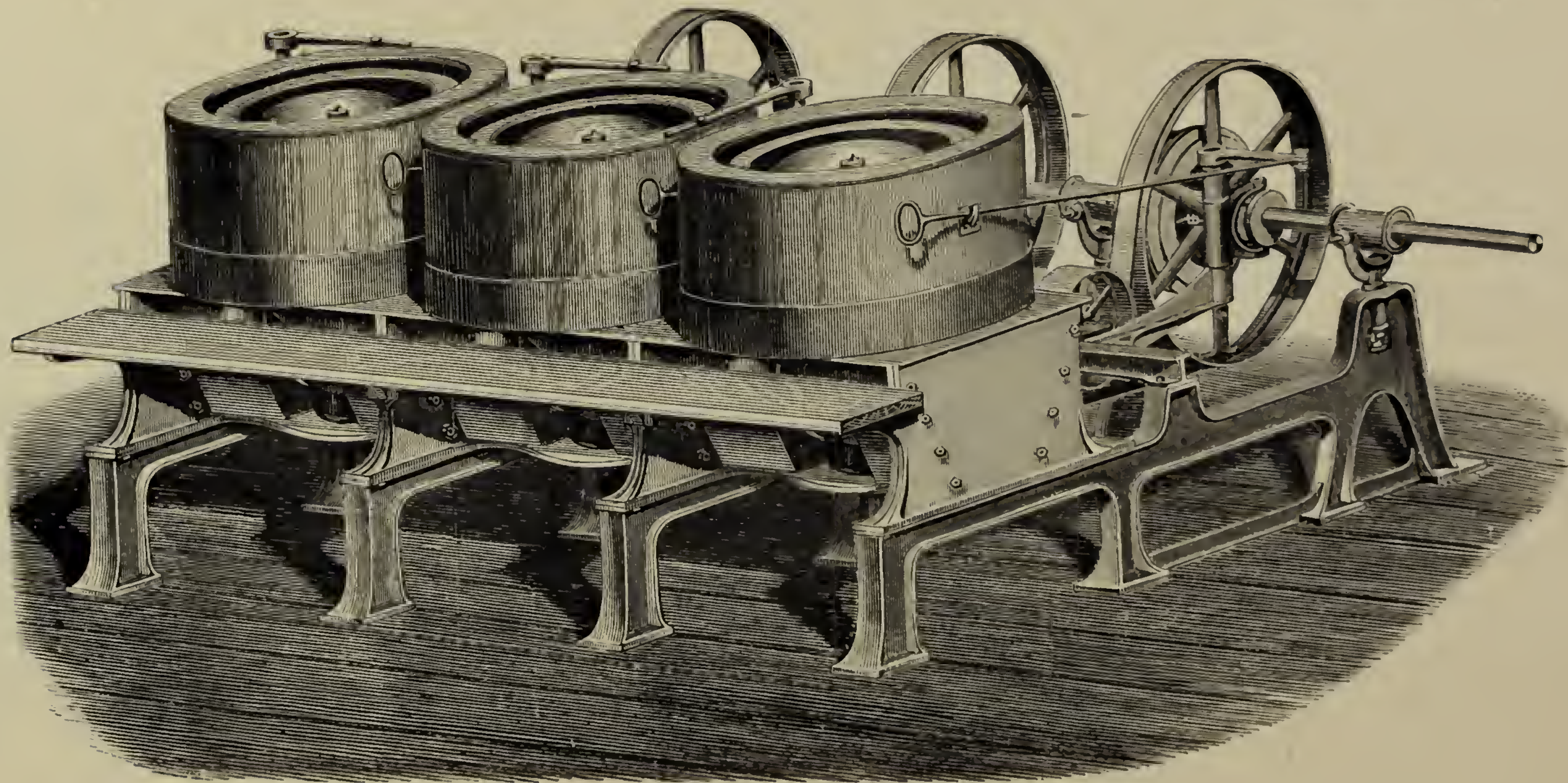
"GERMAN STYLE" CENTRIFUGAL.

Plate XXIII.



HANGING CENTRIFUGAL.

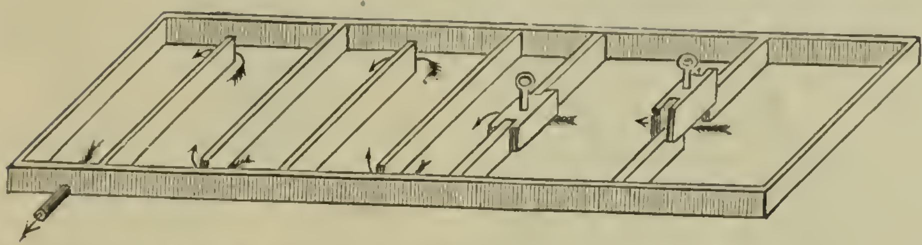
Plate XXIV.



IMPROVED CENTRIFUGAL.

Plate XXV.

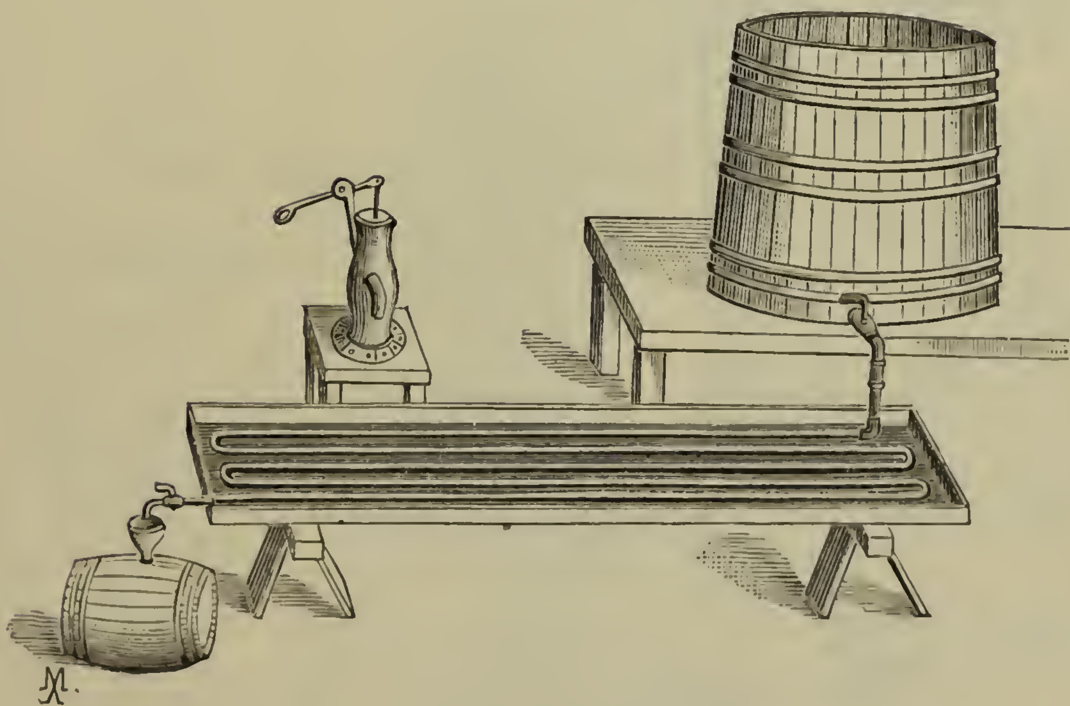
Fig. 1.



COMMON FLAT EVAPORATING PAN.

Wooden sides and partition.

Fig. 2.



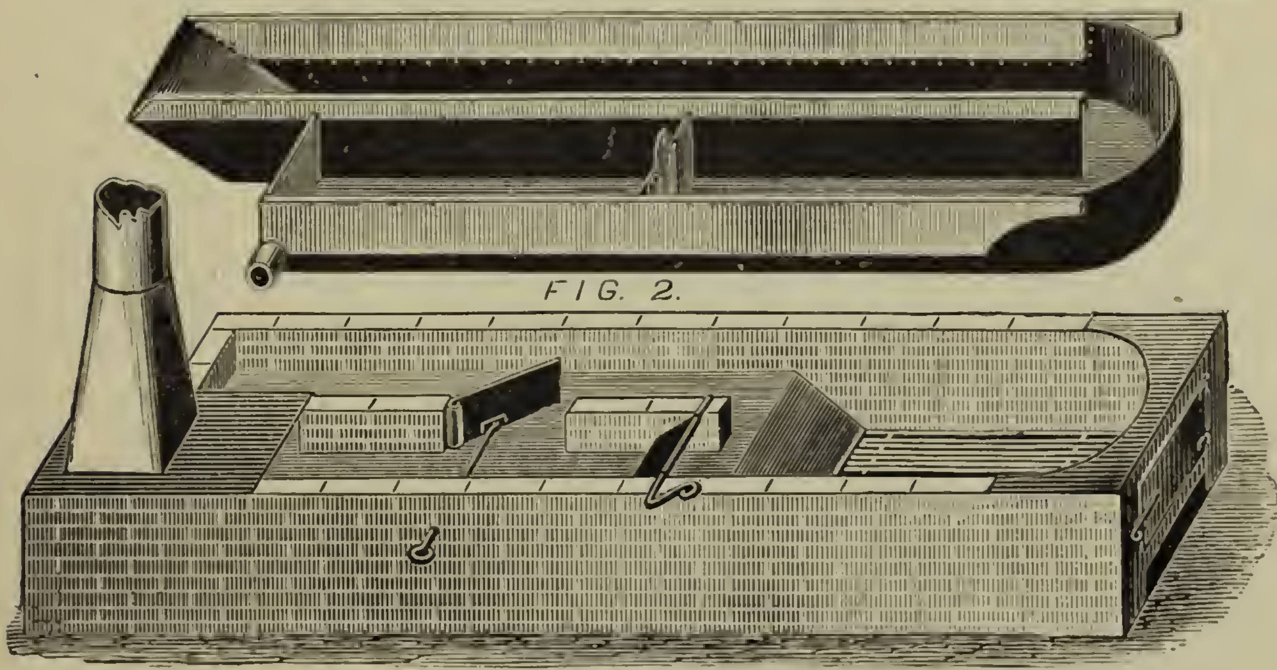
COOLING PAN.

The hot sirup passes through the iron pipe immersed in cold water.

Plate XXVI

DAVID WATSON'S EVAPORATOR.

Plate XXVII.



STUBB'S EVAPORATOR.

Plate XXVIII.

MENT OF AGRICULTURE.

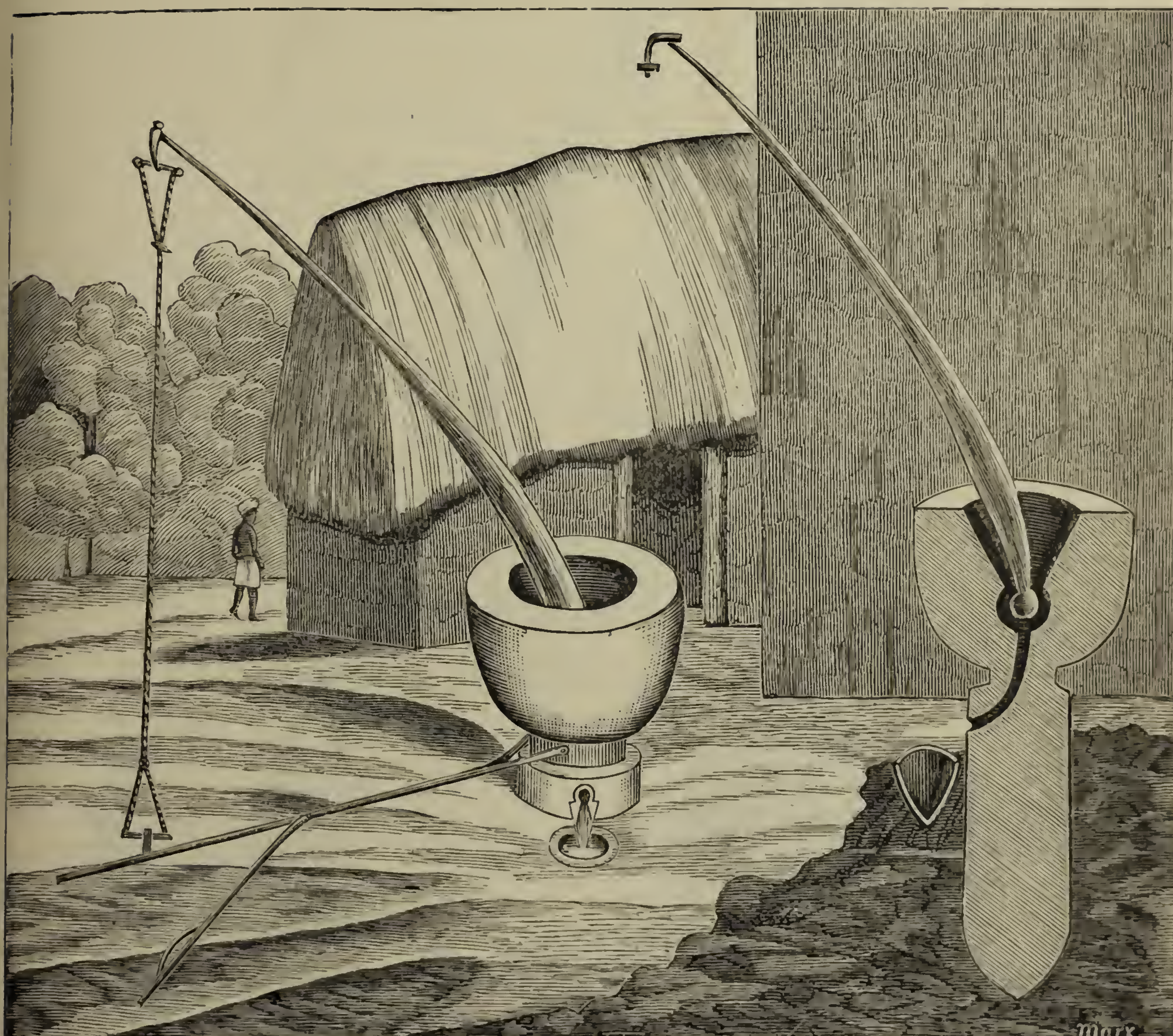
ment of Agriculture. Description in the Chemist's Report.]

Plate XXVIII.

SUGAR MACHINERY OF THE DEPARTMENT OF AGRICULTURE.

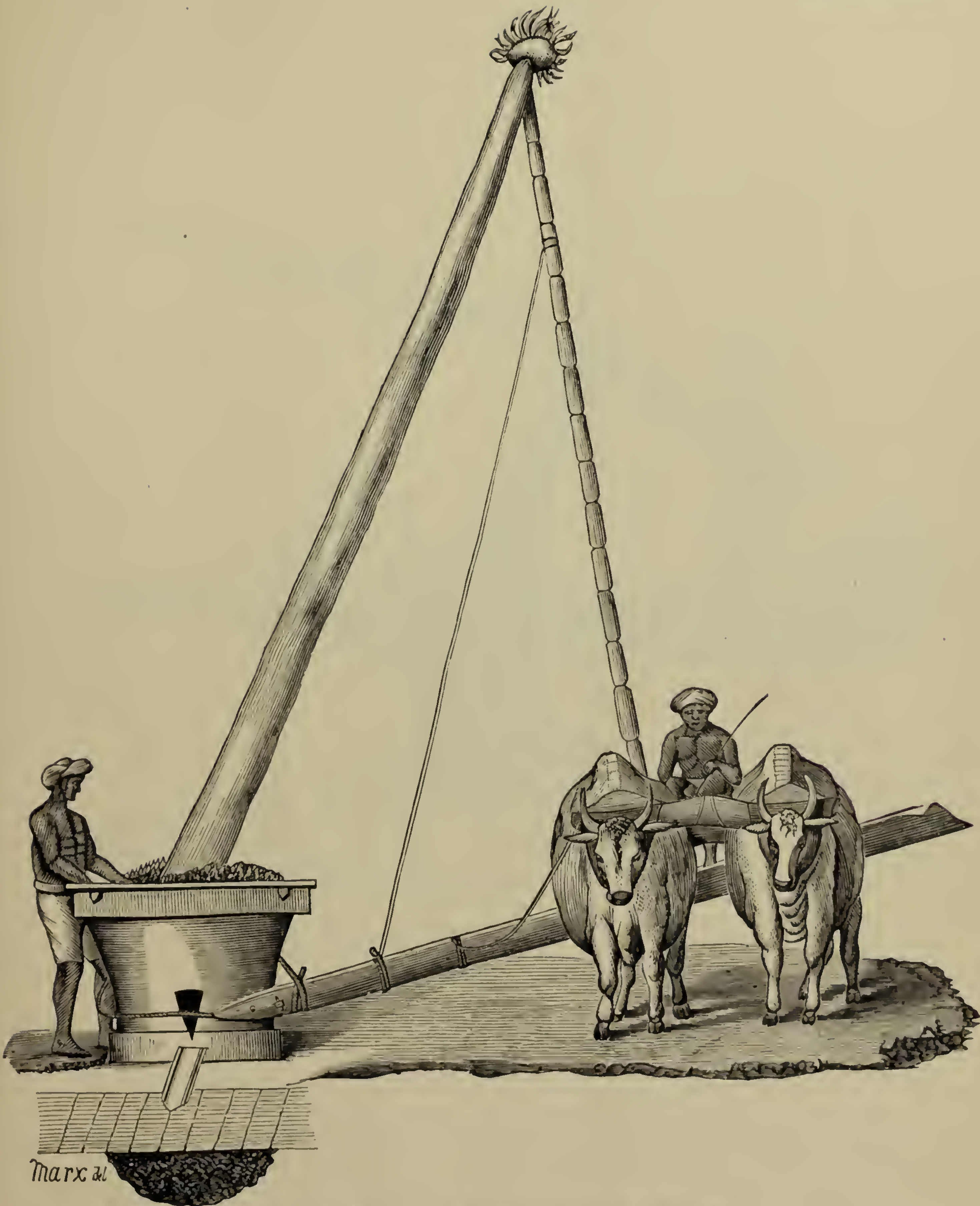
[United States Sugar Mill. Experiments for two years on grounds of Department of Agriculture. Description in the Chemist's Report.]

Plate XXIX.



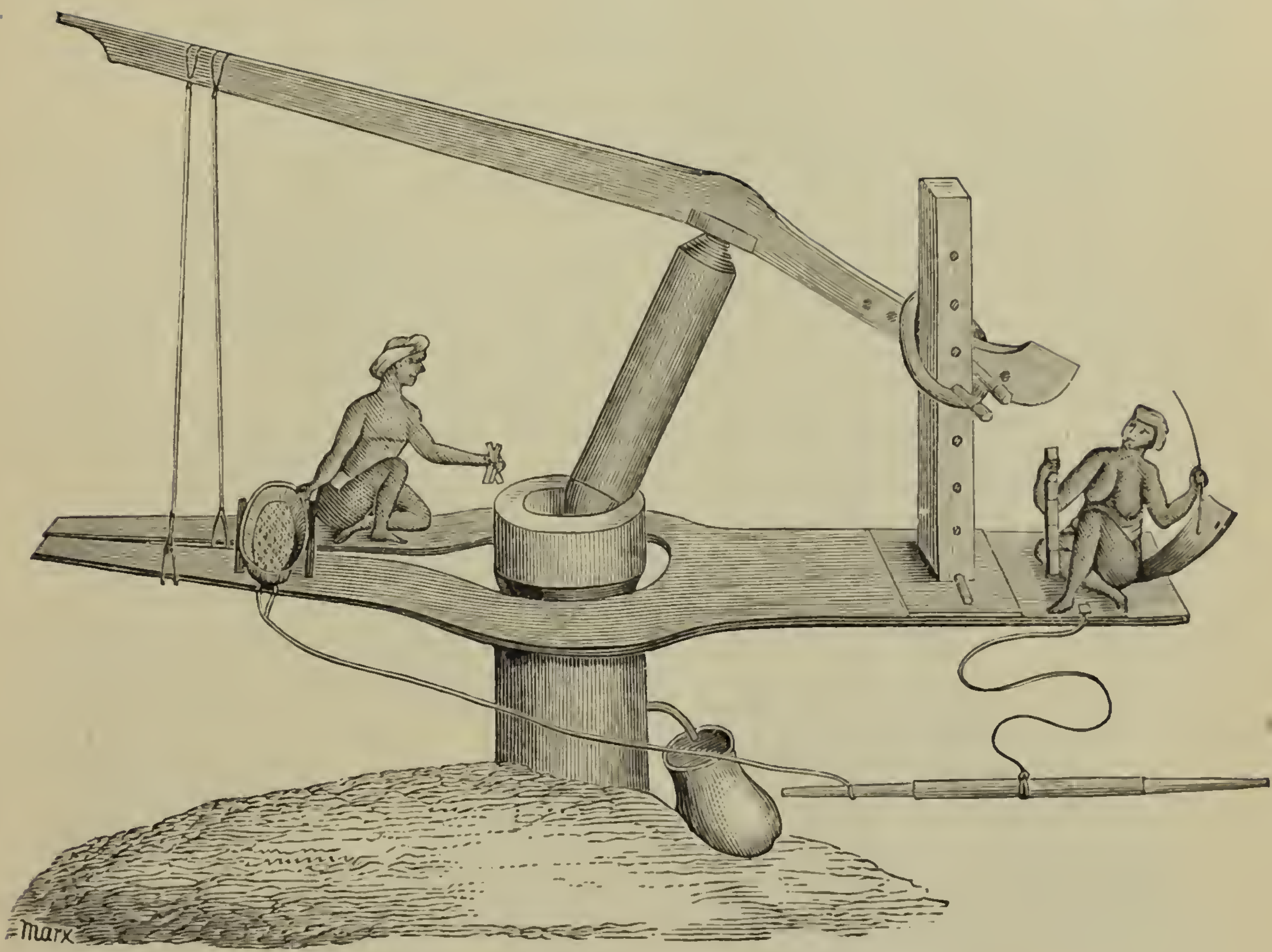
SUGAR MILL IN HINDOOSTAN IN 1800.

Plate XXX.



SUGAR MILL IN HINDOOSTAN IN 1800.

Plate XXXI.



SUGAR MILL IN HINDOOSTAN IN 1800.

Plate XXXII.

IN 1792.

SUGAR MACHINERY IN HINDOOSTAN IN 1792.

Plate XXXIII.

Fig. 2.

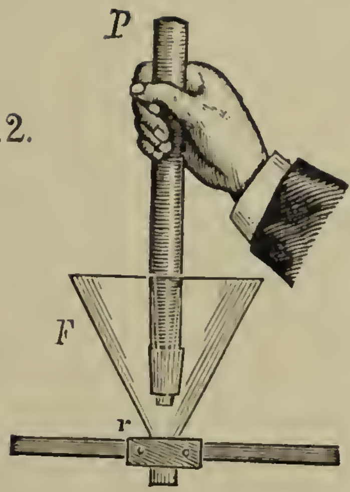
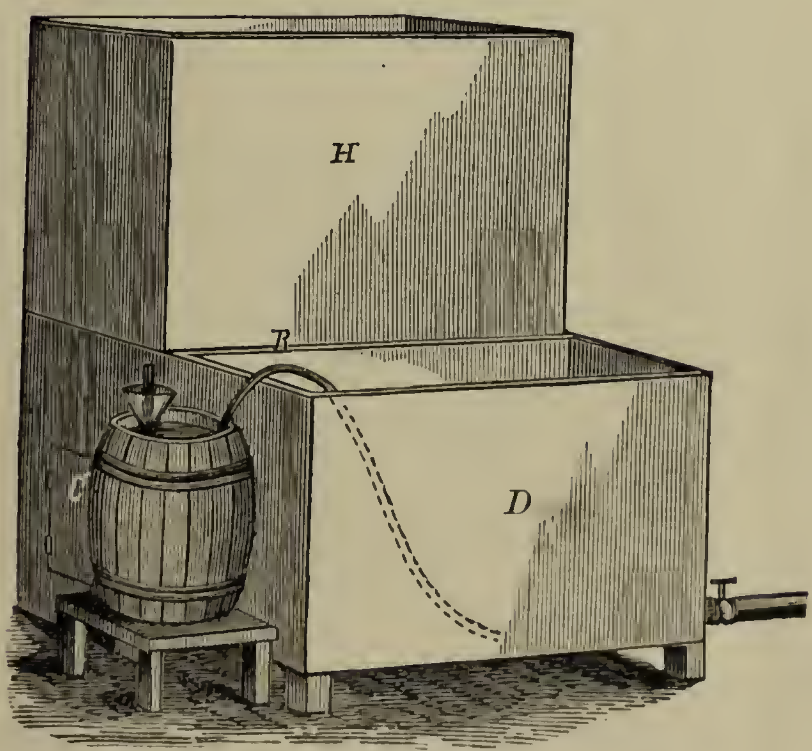


Fig. 1.



MACHINERY USED IN STEWART'S PROCESS.

Illinois Industrial University.

REPORT ON THE MANUFACTURE

OF

Sugar, Syrup, and Glucose

FROM

SORGHUM.

Based upon Experiments made in 1880 and 1881, at the

Illinois Industrial University,

BY

HENRY A. WEBER, Ph. D.,

Professor of Chemistry,

AND

MELVILLE A. SCOVELL, M. S.,

Professor of Agricultural Chemistry.

CHAMPAIGN, ILL.
GAZETTE STEAM PRINT.

1881.

S. H. PEABODY, LL.D.,

REGENT ILLINOIS INDUSTRIAL UNIVERSITY.

SIR:

The undersigned have the honor to submit herewith their complete report of experiments in the manufacture of sugar from sorghum, made at the Illinois Industrial University during the seasons of 1880 and 1881.

Very Respectfully,

H. A. WEBER, Prof. Chemistry.

M. A. SCOVELL, Prof. Agricultural Chemistry.

INTRODUCTION.

The object of the investigations made upon sorghum cane at the Illinois Industrial University, was to settle, if possible, the much disputed question, whether sugar could be made from this plant on a manufacturing scale and with commercial success. From the many conflicting reports relating to this matter no definite conclusions could be drawn, and it was found necessary, in order to prosecute our work in an intelligent manner, to treat the whole subject as an entirely new field of investigation. It has been claimed by many, that the proper sphere of the sorghum industry is the production of sirup, and a great deal of good work has been accomplished in improving the quality and yield of this article. But what may have been true for sorghum a few years ago does not hold good to-day. The sorghum industry is at the present time confronted by another, namely, the glucose industry, which although still in its infancy has already shown its superiority in the production of sirup both in regard to quality and quantity. This statement is made with due consideration of the many attacks which the glucose industry has of late received. Glucose as an article of food is equal to if not superior to cane sugar, and its artificial production from corn or other amylaceous substances is a perfectly legitimate business. It is true, that in the decolorization of the glucose injurious substances may be employed, and if the products sent to market are not perfectly free from them, great injury may be done to the consumers. The same thing may be said for the refining of cane sugar. But in either case the employment of injurious substances is not a necessity and should be condemned by every one who is interested in public welfare. Glucose, when made as it should be, is perfectly harmless, and no valid objection can be made to it in a sanitary point of view, when employed for any legitimate purpose to which it is adapted. The sorghum industry must regard the manufacture of glucose as a fair competitor, and the latter will never lose in importance by any unjustifiable attacks or criticisms. From these considerations it seems evident, that the production of sirup alone can no longer maintain the cultivation of sorghum on a scale which would suffice to give it the name of an industry.

To accomplish this sorghum growers should turn all their attention and energy to the production of crystallizable sugar, which glucose on account of its inherent properties can never replace, and which will always find a ready market free from all competition.

These circumstances led to the investigations about to be described, and the results obtained have exceeded our most sanguine expectations. Our experiments, both scientific and practical, have shown beyond a doubt, not only that the manufacture of sugar from sorghum in our own state is practicable, but also that it will be highly renumerative, when undertaken on a large scale.

Up to the present time sorghum seed has never found a proper utilization. Although in its general composition it resembles other grain as corn, the amount of tannin contained in it, as our analysis given farther on shows, will no doubt prevent its liberal use as food for animals. Knowing that immense quantities of seed will necessarily be produced as soon as the sorghum sugar industry is introduced, we have given this matter careful study, and have found, that the seed is eminently adapted for the production of glucose. We have prepared the glucose directly from the ground seed, without the tedious and expensive process of first separating the starch The great advantage of this industry to the sorghum industry will appear from the fact, that as the seed is practically ripe when the cane is cut it can be stored up until the sugar season is over, and can afterwards be manufactured into glucose with the same machinery now used in making sugar from the cane, thus giving employment for the balance of the year to the works, which otherwise would have to lie idle for eight or ten months annually.

Our work occupied two distinct fields of experiments: first, scientific investigations, in which the nature of sorghum cane was studied; second, practical experiments in making sugar.

PERIODICAL EXAMINATION OF THE CANES FOR SUGAR.

The objects of these analyses were:

1. To note the development and changes of the sugars in the plant during its growth.

2. To notice the changes which the cane undergoes after reaching this maximum stage in the quality and quantity of its saccharine matter: first, while standing in the field untouched; second, standing stripped two weeks; third, cut and lying under shelter.

3. To ascertain the portion of the stalk richest in sugar.

4, To study the effect of different varieties of soils on the development of sugar in the cane.

5. To determine the effect of freshly manured soils on the development of sugar in sorghum.

6. To compare the different varieties of sorghum as sugar producing plants.

These examinations were conducted in the following manner:

On the dates specified, ten average stalks were selected from the given field, stripped, topped just below the uppermost leaf, and cut off one joint above ground. The stripped and topped cane was crushed in a thoroughly cleansed Victor mill. The juice was collected in a bottle and after being cooled down to 20 ° c., the sp. gr. was noted, then 10 c.c. were put into a graduated cylinder for the estimation of grape sugar, and 10 c.c. were put in a beaker for determining the amount of cane sugar.

For the estimation of grape sugar the 10 c.c. measured off for this purpose were diluted so as to measure exactly 100 c.c. and the grape sugar then determined by Fehling's solution.

The portion reserved for cane sugar was diluted, 12 drops of dilute sulphuric acid added, and the whole heated over a water bath for one hour. The mixture was then allowed to cool, sodium hydroxide added to alkaline reaction, diluted to 500 c c., and the total amount of sugar determined with Fehling's solution. The difference between the grape and total sugar was estimated as cane sugar by multiplying by 0.95.

The results of the analyses are given in the tables which follow:

TABLE SHOWING THE DEVELOPMENT AND CHANGE OF SUGARS IN SORGHUM.

Stage of Development.	No.	Date.	Variety.	Sp. gr. of Juice.	Grape Sugar.	Cane Sugar.	Av. of Cane Sugar.
Beginning to head.	1	Aug 14, '80.	Orange.	1.055	5.70	4.90	4.1
	2	Aug. 10, '81.	Amber.	1.058	8.39	3.38	
In blossom.	3	Aug. 25, '80.	Orange.	1.062	6.10	7.12	7.77
	4	Aug. 10, '81.	Amber.	1.066	5.43	8.42	
Seed soft and milky.	5	Aug. 14, '80.	Amber.	1.065	3.34	10.75	8.56
	6	Sept. 6, '80.	Orange.	1.068	5.00	9.13	
	7	Aug. 10, '81.	Amber.	1.068	4.25	9.84	
	8	Aug. 12, '81.	Amber.	1.070	3.75	12.75	
	9	Sept. 1, '81.	Orange.	1.048	6.11	3.71	
	10	Sept. 2, '81.	Orange.	1.048	6.58	5.19	
Seed in hardening dough.	11	Aug. 25, '80.	Amber.	1.068	2.47	12.48	11.95
	12	Sept. 16, '80.	Orange.	1.065	4.11	9.76	
	13	Aug. 10, '81.	Amber.	1.074	3.65	10.10	
	14	Aug. 12, '81.	Amber.	1.074	2.65	13.37	
	15	Aug. 16, '81.	Amber.	1.070	3.92	11.89	
	16	Aug. 16, '81.	Amber.	1.072	3.00	13.66	
	17	Aug. 19, '81.	Amber.	1.067	3.46	12.49	
	18	Aug. 19, '81.	Amber.	1.074	3.10	13.18	
	19	Aug. 19, '81.	Amber.	1.076	2.97	13.64	
	20	Aug. 19, '81.	Amber.	1.070	2.98	12.80	
	21	Aug. 19, '81.	Amber.	1.070	3.26	12.52	
	22	Sept. 1, '81.	Liberian.	1.060	3.67	10.24	
	23	Sept. 1, '81.	Amber.	1.063	2.61	13.47	
	24	Sept. 1, '81.	Amber.	1.056	2.18	11.14	
	25	Sept. 1, '81.	Chinese.	1.052	4.13	8.60	
Seed ripe.	26	Sept. 6, '80.	Amber.	1.064	2.13	11.42	11.18
	27	Sept. 16, '80.	Amber.	1.065	2.79	11.02	
	28	Oct. 2, '80.	Amber.	1.069	2.47	10.06	
	29	Oct. 6, '80.	Orange.	1.078	4 02	11.41	
	30	Sept. 9, '81.	I. I. U.	1.070	2.93	12.48	
	31	Sept. 1, '81.	Amber.	1.070	2.71	10.77	
	32	Sept. 2, '81.	Amber.	1.070	2.61	10.57	
	33	Sept. 5, '81.	Amber.	1.067	3.16	11.76	

The analyses made in 1880, numbers 1, 3, 5, 6, 11, 12, 26, 27, 28, and 29, were from cane grown upon the University farm.

The following data in regard to the planting and cultivation of the cane were furnished by G. E. Morrow, Professor of Agriculture:

Two varieties, Orange and Early Amber; seed obtained from Hedges. St. Louis; planted by hand, May 14, 1880. The Orange was planted in a plot of nearly one acre (.955) in 24 rows four feet apart, in hills about four feet in a row. The Early Amber was planted in a plot of one and one-half acres (1.48) in 40 rows three and one half feet apart, and with hills abont same distance apart. Each plot was on good prairie soil which had been in corn two years, following a liberal application of barn-yard manure. The plots received ordinary field culture—a two-horse corn cultivator,—except hand-hoeing and thinning to four or five stalks when ten to twelve inches high. The suckers were not removed. The Orange averaged about seven feet in height, and over an inch in diameter at base. The Early Amber averaged over nine feet in height, and rather less than three-quarters of an inch in diameter at base. The canes were cut about six inches from the ground. Of the Orange, from two to three feet of the top was taken off; of the Early Amber, rather more than three feet.

An analysis was made of the soil on which these two varieties of cane grew, and also of its subsoil and of a virgin prairie soil adjoining.

The following table gives the result of these analyses. No. 1 was prairie soil, No. 2 the soil on which the cane grew, No. 3 its subsoil:

Soil.	No. 1.		No. 2.		No. 3.	
Organic matter	1.9414		2.4880		3.7551	
Silicic acid	0.0798		0.0617		0.0975	
Sesquioxide of iron	1.8367		1.4517		1.2650	
Alumina	1.4775		0.5700		1.7150	
Manganese	0.1798		0.2200			
Phosphate of lime	0.1683		0.2103		0.1152	
Carbonate of lime	0.3835		0.5845		1.2515	
Carbonate of magnesia	0.5244		0.6757		0.7140	
Potash	0.0733		0.0785		0.0505	
Soda	0.0177		0.0211		0.0970	
Sulphuric acid	0.1403		0.1519		0.2137	
Soluble matter found		6.8327		7.5134		9.2745
Organic matter	4.1150		6.0700		8.9549	
Silicic acid	72.1765		68.7127		68.0224	
Alumina with trace of iron	12.7143		12.0520		9.3156	
Lime	0.5729		0.7721		0.6444	
Magnesia	0.4893		0.4831		0.4836	
Potash	3.0041		3.0331		2.4561	
Soda	0.5120		0.6344		0.5664	
Manganese	0.0093		0.0847			
Phosphoric acid	0.1933		0.1553		0.2628	
Insoluble matter found		92.7867		91.9974		90.7062
	99.6194	99.6194	99.5108	99.5108	99.9807	99.9807

Analyses Nos. 2, 4, 7, and 13, were made from cane grown upon the farm of Mr. J. W. Cushman, two miles south of Urbana. The field on which this cane was planted had grown seven consecutive crops of sorghum, without manure. It was high prairie land sloping towards the south. Seed planted April 25.

The cane of Nos. 8 and 14 was grown about one and one-half miles N. E. of Urbana, on timber land. The field had been used as a barnyard previous to its being planted with cane and was therefore richly manured. The seed came from Minnesota through Mr. Le Duc, ex-Commissioner of Agriculture. The seed was planted the first week in May. Cultivated as usual for corn.

Results Nos. 15 and 16 were obtained from cane grown three miles south of Champaign, on virgin prairie. Eight rows were planted along the roadside, bounded on the outer side by the road itself and the inner by a tall, dense hedge-fence. Mr. Holmes, the owner of the cane, said the seed came from Mississippi and was planted the last week In April. Land gradually rising from a slough near by. Two varieties of heads were present in this cane: the panicles of one (analysis No. 15) were clustered and erect; those of the other (No. 16) were spreading with pedicels drooping.

No. 21, University farm. Volunteer cane, from cane grown on the field last year.

The cane from which analyses Nos. 17, 18, 19, and 20 were made, was grown upon timber land about three miles N. E. of Urbana. The seed probably came from Minnesota.

No. 17. Cane grown by Mr. E. Bishop. Field ten years in cultivation, manured three or four years ago. Seed planted about the middle of May. Rows 3½ feet apart in hills 3 feet apart. An average of eight stalks in a hill. Cane small. Nos. 18 and 19, cane grown by Christ. Shuman. No. 18 was on high land, twelve years in cultivation and had never been manured. An average of five stalks in a hill. Growth of cane medium. No. 19 was on low land, four years in cultivation. Average of eight stalks in a hill. Cane large and thrifty.

No. 20. Cane grown by Sam'l Wilson, on land four years in cultivation. Hills 3x3½ feet apart. An average of eight stalks in a hill. Field on the top of a small hill.

Analyses Nos. 9, 10, 22, 31, and 32. were made in Macoupin county, Illinois, Nos. 9, 22, and 31 from cane raised about two miles north of Virden, by Mr. Chas. Rauch, and Nos. 10 and 32 one mile west of Girard, by Mr. D. C. Ashbaugh. The prairie soil in this county is very black, deep, and "mucky." No. 9. Cane grown on timber land. Seed planted May 12, 1881. Hills 3 by 3, an average of five stalks in a hill. No. 22. Volunteer cane. Prairie land. No. 31. Prairie land. Seed planted first part of May. No. 32. Prairie land; seed planted latter part of May.

The results of experiment No. 53 were obtained from cane grown by Christ. Lust, about a mile west of Monticello, Piatt county. The field was timber land—a poor, clayey soil. Seed planted first week in May.

Analyses Nos. 23, 24, and 25 were made of the juice of sorghum grown upon the so-called Mississippi sand-lands near Oquawka, Illinois. No. 23 was from cane grown by Dr. Park, one mile east of Oquawka. Nos. 24 and 25 were made from cane grown by Tom Ricketts, two miles N. E. of same place.

Development of sugar. Analyses Nos. 5, 11, 26, 27, and 28 were made from the same field on the dates specified, and show conclusively that the cane sugar reached its maximum quantity when the seed was in the "hardening dough," and that it afterwards gradually diminished. The same fact appears on comparing the average under each division in the table.

Effect of stripping and allowing to stand. On October 2d, 1880, an analysis was made of the juice of cane, which had been stripped on the 18th of September,—the cane not otherwise disturbed—with the following result:

Specific gravity of juice	1.074
Grape sugar	1.82 per cent.
Cane sugar	13.11 "

This subject needs further investigation.

Change of sugar after cutting the cane. On October 23, 1880, an analysis was made of the juice of the Orange cane which had been cut, stripped, and topped October 2 and placed under shelter until examined. Juice whitish.

Specific gravity	1.091
Grape sugar	14.66 per cent.
Cane sugar	3.55 "

A sample of cane, cut August 25, 1880, without being stripped and topped, was preserved in a warm room where it had become dry long before it was examined. On April 3, 1881, it was analyzed and showed 12 per cent. of grape sugar and no trace of cane sugar.

Comparison of the upper and lower half of the cane. The two following analyses were made to show what part of the cane is richest in sugar:

Amber—October 2, 1880. Juice obtained from the upper half of the stalks after topping as usual.

Specific gravity	1.069
Grape sugar	2.94 per cent.
Cane sugar	9.67 "

Amber—October 2, 1880. Juice obtained from the lower half of stalks.

Specific gravity	1.070
Grape sugar	1.94 per cent.
Cane sugar	11.64 "

Effects of soils. The following analyses were made to study the effect of different varieties of soil upon the production of sugar in sorghum. But as other circumstancs, as locality from which seed was obtained, time of planting, and manner of cultivation, may effect the amount of sugar, many more investigations would have to be made before definite conclusions could be reached. The table, however, shows that sorghum can be grown successfully on all varieties of soil specified.

Table showing the effects of different soils on the development of sugar in sorghum :

Variety of soil.	No.	Years in Cultivation.	Fertilization.	Variety of Cane.	Sp. gr. of Juice.	Grape Sugar.	Cane Sugar.	Av'ge.
Prairie.	1	27	Manured 3 yrs. ago.	Amber.	1.068	2.47	12.48	Grape. 2.94
	2	7	No manure.	Amber.	1.074	3.65	10.10	
	3	27	Manured 4 yrs. ago.	Amber.	1.070	3.26	12.52	Cane.
	4	Unknown.	No manure.	Amber.	1.07	2.71	10.77	11.28
	5	Very old.	No manure.	Amber.	1.07	2.61	10.51	
Virgin prairie.	6		No manure.	Amber.	1.07	3.92	11.89	Grape. 46
	7		No manure	Amber.	1.072	3.00	13.65	Cane. 12.77
Timber land.	8	Unknown.	Barn-yard manure.	Amber.	1.074	2.65	13.37	
	9	10	Manured 4 yrs. ago.	Amber.	1.067	3.46	12.49	Grape.
	10	12	No manure.	Amber.	1.074	3.10	13.18	3.07
	11	4	No manure.	Amber.	1.076	2.97	13.64	Cane.
	12	4	No manure.	Amber.	1.07	2.98	12.80	12.87
	13	Many.	No manure	Amber.	1.066	3.16	11.76	
Mississippi sand land.	14			Amber.	1.063	2.61	13.47	Grape. 2.39
	15			Amber.	1.056	2.18	11.14	Cane. 12.3

Effect of Manure.—To ascertain the effect of manure a field was selected which had been used as a barn-yard for several years. A part of the cane was planted directly on the rotten manure pile. An analysis was made of a sample taken from this part of the field, as well as of a part away from the manure pile. The seed in each case was in the "hardening dough." The following is the result of the analysis:

Manured—Sp. gr. 1.063. Grape sugar 2.65. Cane sugar 10.89.
Unmanured " 1.074. " " 2.65. " " 13.37.

Variety of Cane.—From the table it appears that the Amber is best adapted for the production of cane sugar. The Orange and Liberian can also be employed advantageously in the latter part of the season, as they mature later. Their yield is greater per acre, and this fact no doubt would compensate for the less proportion of cane sugar to grape sugar contained in them. Analysis No. 25 of the Chinese cane seems to indicate that it would be unfit for the production of crystallizable sugar.

PROXIMATE ANALYSIS OF SORGHUM CANE.

An average portion of the Orange cut at the same time—October 6. as that used in experiment 29 was reserved, with tops and leaves still remaining, for the analysis.

The leaves and two feet of tops were removed, and cross sections taken between each joint of the remainder of the stalks. The proximate principles were then determined according to the following scheme. The sections, as soon as cut, were weighed and then dried in a water oven, allowed to cool in the air, weighed, finally pulverized, and put in a stoppered bottle. Of the dried substance, ten grams were required for sugar, fiber, starch, gum and vegetable acids ; one gram for hygroscopic water and ash ; one gram for total albuminoids ; five grams for oil. The gram of dried cane reserved for water and ash was heated in an oven at 110° C. until its weight was constant. It was then ignited and the ash weighed. The ten grams for the estimation of sugar, etc., were macerated with water in a mortar, the water decanted, and this process continued several times, the decanted liquids being filtered by Bunsen's method, and finally the residue was thrown on the filter and washed until the filtrate measured one litre. 100 c.c. of this solution was evaporated nearly to dryness on a water bath, then the desiccation completed by passing a current of dry air upon the residue by means of an aspirator, the temperature of the substance ranging in the meantime between 90° and 100° C. The residue was then weighed, incinerated, and weight of ash noted.

Albuminoids.—400 c.c. of the aqueous extract were evaporated to a syrup on the water-bath, calcined gypsum added, the whole then dried and the residue ignited with soda lime.

500 c.c. of the aqueous extract were rapidly evaporated nearly to dryness, and the residue exhausted with alcohol of 87 per cent. by repeated boilings with fresh portions of the solvent as long as it was colored. The liquids were filtered, the residue thrown upon the filter and washed with hot alcohol, and the washings added to the filtrate. Water was added to the filtrate, the alcohol expelled by heat, and then the solution diluted to 200 c.c.

Grape Sugar.—100 c.c. of this solution were reserved for the estimation of grape sugar. The remainder was acidulated with dilute sulphuric acid, and boiled to convert the cane into grape sugar.

Cane Sugar.—The cane sugar was then estimated with Fehling's solution, as usual.

Gum and Vegetable Acids.—The residue insoluble in alcohol was dried at 100 C., weighed, and then incinerated. This ash and the soluble albuminoids were subtracted from the total amount of residue, and the remainder estimated as gum and vegetable acids.

The residue left after extracting the ten grams of cane with water was washed with alcohol acidulated with sulphuric acid to dissolve the albuminoids, transferred to a beaker, and diluted to 200 c. c. 5 c. c. of normal sulphuric acid were added, and the whole boiled for an hour on the water-bath, then filtered through Bunsen's filter. The filter was also cut into shreds and boiled with water containing one per cent. of sulphuric acid, to dissolve any starch remaining on it. After filtering, the two filtrates were added, and the starch estimated from an alliquot portion by conversion into glucose.

The method was as follows: The starch solution was diluted to 500 c.c. Three separate portions of 50 c.c. each were transferred to prescription bottles, 10 c.c. normal acid added, the bottles were then stoppered with rubber stoppers firmly tied, and placed in a salt-bath and boiled respectively for three, four, and six hours. The contents of the bottles were then neutralized, diluted, and starch calculated from the amount of grape sugar present. The solution boiled six hours had 0.02 per cent. more starch than that boiled four hours. Three hours' boiling did not convert all of the starch into grape sugar. The residue from which the starch was taken was boiled with sodium hydroxide, thrown upon a weighed filter and repeatedly washed with the same solution, then washed with hot water, and finally with alcohol and then with ether. The washed residue was dried at 110° C. and weighed, then incinerated, the weight of ash subtracted from the former weight, and the difference estimated as fiber. The gram reserved for the albuminoids was ignited with soda-lime, and albuminoids determined as usual.

The oil was extracted by ether from five grams of the dried cane.

The total water was estimated by adding the per cent. of loss of the air dried cane and the hygroscopic water.

RESULTS.

Composition of stalks of Orange cane in one hundred parts:

Water	76.58
Grape sugar	3.00
Cane sugar	9.77
Starch	4.12
Fiber	4.54
Oil	0.07
Gums and vegetable acids	0.24
Soluble albuminoids	0.23
Insoluble	0.16
Soluble ash	0.68
Insoluble ash	0.06
	99.45

ASH.

The ash from the remaining dried cane was analyzed by the following method: The cane was incinerated at a low heat, pulverized, dried and put in a stoppered bottle.

Chlorine.—Two grams of the ash were exhausted with water, silver nitrate added to the extract and the whole acidified with nitric acid. The precipitate of chloride of silver was collected upon a filter, dried, ignited, weighed, and the chlorine calculated in the usual manner. The filtrate was treated with excess of hydrochloric acid, silver chloride removed and the solution preserved.

Silica.—The ash insoluble in water was treated with hydrochloric acid, brought to dryness, moistened with hydrochloric acid, water added, and the residue thrown on a weighed filter. The filter and its contents were heated at 160° C until of constant weight, then ignited and the silica weighed. The loss found between the two weights was called char-coal.

The solution from which the chlorine had been precipitated and the filtrate from the silica were mixed, and the whole diluted to 200 c.c., and well shaken. 50 c.c. of this solution were reserved for the estimation of sulphuric acid and alkalies, 50 c c. for phosphoric acid, manganese, lime, and magnesia.

Iron.—The remaining 100 c.c. were treated with sulphuric acid, and heated upon a water bath until the chlorine was expelled; then transferred to a flask, water and sulphuric acid added, and the iron reduced with hydrogen, generated by zinc suspended in the liquid, by means of a platinum wire. To facilitate the operation, a strip of platinum was introduced into the flask and allowed to come in contact with the zinc. After the reduction, the iron was estimated by a standard solution of potassium permanganate.

Phosphoric Acid.—A solution of ferric chloride was added to the portion reserved for phosphoric acid, etc., in sufficient quantity for the iron to combine with all the phosphoric acid present. Sodium carbonate was added until the last drop caused a precipitate, which did not re-dissolve upon agitation. The mixture was then heated, a hot solution of sodium acetate added, and the whole brought to the boiling temperature, filtered, and washed with hot water.

The residue was dissolved in nitric acid and concentrated to about 10 c.c.; a nitric acid solution of molybdate of ammonia was added in excess, and the mixture allowed to stand in a warm place for 24 hours. The precipitate was collected on a filter, the beaker rinsed, and the contents of the filter washed with a mixture of the molybdate solution and water. The precipitate was dissolved in the smallest quantity of ammonia. Any of the phospho-molybdate precipitate remaining in the beaker was dissolved in a mixture containing 3 parts of water and 1 of ammonia and thrown upon the filter; finally, the filter was washed with the ammoniacal water. The filtrate was boiled, and the phosphoric acid precipitated with a mixture of ammonium-chloride, magnesium-sulphate and ammonia, made according to Fresenius' formula. After allowing the mixture to stand 12 hours, the precipitate was collected on a filter, washed with ammonia water, and the volume of the filtrate and washings noted.

The precipitate was ignited in a platinum crucible, a little nitric acid added, and again ignited to oxidize the charred matter present, cooled, and weighed. As ammonia-magnesia-phosphate is soluble in about 54,000 parts of ammoniacal water, .003 of a gram was added to this weight, as the filtrate measured a little over 150 c.c. The phosphoric acid was then calculated from this weight of pyrophosphate of magnesium.

Manganese.—The solution from which the iron and phosphoric were precipitated was treated with a few drops of bromine, and boiled to precipitate the manganese. The precipitate was collected upon a filter and thoroughly washed, then strongly ignited, and weighed.

Lime.—The above filtrate was concentrated, and while hot a little ammonia added, and then an excess of ammonium oxalate, to precipitate the lime. The mixture was allowed to stand 12 hours. The precipitate was then collected upon a filter, washed, dried, and ignited in a platinum crucible. After the filter was reduced to ash, carbonic acid was passed over the ignited lime, to reconvert any oxide formed into carbonate. From the weight of calcium-carbonate thus obtained the per cent. of lime was calculated.

Magnesia.—The filtrate from the lime was concentrated, ammonia added in excess, and then a solution of phosphate of soda to precipitate the magnesia present. This precipitate and its filtrate were treated the same as the corresponding one, the estimation of phosphoric acid. The magnesia was calculated from the amount of pyrophosphate of magnesia found..

Sulphuric Acid.—The 50 c.c. of the solution reserved for this purpose were boiled, and the sulphuric acid precipitated, with a slight excess of barium-chloride. The precipitate was collected upon a filter, washed, ignited and weighed.

Potassa.—The above solution was treated, after concentration on a water-bath, with ammonia and ammonium-carbonate as long as any precipitate was formed, digested on a water bath, filtered, and the contents of the filter carefully washed. The filtrate and washings were evaporated to dryness on a water bath, and the residue ignited to expel ammoniacal salts. This residue was then treated with five and one-half times its weight of pure oxalic acid in the form of a concentrated solution, then evaporated to dryness, and again ignited to dull redness. The ignited residue was treated with a small quantity of boiling water, thrown upon a filter, washed with hot water, hydrochloric acid added to the filtrate, the mixture evaporated to dryness, and gently ignited, and the weight of the alkaline chlorides ascertained.

The separation of the alkalies was effected with platinic chloride, as follows:

The residue of alkalies was dissolved in a little water, and enough platinic chloride added to combine with the alkalies estimated as potassium salt. This mixture was evaporated nearly to dryness over a water bath, care being taken not to boil the water. A mixture of six volumes of alcohol and one of ether was poured over the residue, and the whole allowed to stand several hours in a covered vessel, with occasional stirring. The insoluble potassio-platinic chloride was transferred to an equipoised filter, washed with alcohol and ether mixed, and finally dried at 100° C., and weighed.

Soda.—From the weight of the double potassium chloride, the amount of the potassium chloride was ascertained. The weight was subtracted from the weight of the combined alkali chlorides, and the remainder called sodium chloride, and calculated as soda.

Carbonic Acid.—One gram of the ash was transferred to a Rose carbonic acid apparatus, and the carbonic acid estimated by loss. The following were the results obtained:

Composition of Ash.—

Silica	27.91
Iron oxide	0.14
Phosphoric acid	5.37
Manganese oxide	0.89
Lime	6.82
Magnesia	4.64
Sulphuric acid	6.23
Potassa	46.48
Soda	0.98
Sodium chloride	0.42
	99.88

ANALYSIS OF SORGHUM SEED.

A sufficient quantity of the seed was ground as fine as possible in an iron mortar, and was preserved in a glass-stoppered bottle.

The following portions of the ground seed were taken:

10 grams, for the estimation of sugar, dextrine, starch and fiber.
1 gram, " " water and ash.
1 " " " albuminoids.
1 " " " oil.
1 " " " tannin.

Sugar, etc.—The ten grams reserved for sugar, etc., were rubbed up thoroughly with water in a mortar, then transferred to a filter and washed well with water.

Solution=A.
Residue=B.

The solution, A, was concentrated to about 10 c.c. in a porcelain dish on a water bath, then transferred into a strong prescription bottle and washed with about 10 c.c. of water, and the washings added. 5 c.c. of normal sulphuric acid were added, the bottle closed with a rubber stopper securely tied. The bottle and its contents were then transferred to a salt bath and boiled for six hours. After cooling, the contents of the bottle were transferred to a graduated cylinder, neutralized and diluted to 100 c.c., the coloring matter precipitated with acetate of lead, and, after thoroughly mixing, the whole was allowed to stand until the precipitate had settled to the bottom. A portion of the clear liquid was then transferred to a burette and dropped into 10 c.c. of Fehling's solution, diluted four times, and at the boiling temperature, until the whole of the copper had been precipitated as cuprous oxide. This point was determined by filtering a small quantity from time to time, acidifying the filtrate with acetic acid, and testing for copper with ferro-cyanide of potassium. The number of c.c. of the sugar solution it took was noted, and the sugar and dextrine determined by the following proportion:

1. The number of c.c. it took to precipitate copper solution : total number of c.c. : : .05 (grains of grape sugar required to precipitate 10 c.c. of Fehling's solution) : x.

X multiplied by 0.95 will give the grams of sugar in 10 grams of seed.

The residue, B, was washed on the filter with alcohol acidulated with sulphuric acid and finally with water, to dissolve the gluten. Then the residue was washed off the filter into a beaker diluted to about 400 c.c. 5 c.c. of sulphuric acid added, and the whole boiled on a water bath until the liquid had no milky appearance. It was then filtered through an equipoised filter and washed.

Solution=C.
Residue=D.

Solution C was diluted to 500 c.c. 50 c.c. of this solution were transferred to a prescription bottle and then treated as above for sugar and dextrine. From the grape sugar obtained, the amount of starch was calculated.

Residue D was boiled with hot sodium hydroxide, again thrown upon the filter and washed with the same solvent; afterwards, with hot water, then with alcohol, and finally with ether. The washed residue was dried at 119° C., weighed, ignited, and the amount of ash deducted. The remainder was estimated as fiber.

Water.—For the estimation of water, the ground seed was weighed in a glass-stoppered test tube. After weighing, the glass stopper was replaced by a rubber one, through which passed two glass tubes, bent at right angles. One of these tubes was connected with an aspirator; the other, with a calcium chloride tube and a sulphuric acid drying bottle. The test tube and its contents were then placed in an opening of a drying oven, whose temperature was between 100 and 110° C. During the operation, a current of air, passing through the sulphuric acid and calcium chloride tube, thus drying it, was drawn into the tube and the moisture sucked out by means of the aspirator. When the weight became constant, the loss was estimated as water.

Ash.—The contents of the tube were transferred to a platinum crucible, incinerated, and ash weighed.

Albuminoids.—One gram of the ground seed was ignited with soda lime. The substance was intimately mixed with a portion of soda lime sufficient to fill a 14-inch combustion tube two-thirds full. About two inches of the tube were filled with soda-lime, then the mixture of soda lime and substance added, the mortar rinsed with soda-lime, and finally the rinsings and enough soda lime added to nearly fill the tube. A plug of asbestus was put in, and the tube gently tapped to insure an air passage throughout its length.

Will's bulbs were charged with a deci-normal solution of oxalic acid. The tube being placed in the combustion furnace was connected with the bulbs. The fore part of the tube, containing the soda-lime only, was heated to redness, then heat applied, one jet at a time, along the entire length of the tube, care being taken that the combustion was completed in that portion of the tube where heat was applied before other jets were turned on, and also that the combustion was not too rapid. After the combustion was ended, the contents of the bulbs were transferred to a beaker, tincture of litmus added, and the excess of acid titrated with a deci-normal solution of potassa. The amount of ammonia found to be present was calculated as nitrogen, The nitrogen was multiplied by 6.25, and the result called albuminoids.

Oil.—The one gram of ground seed reserved for the estimation of oil was placed in a short test-tube, the bottom of which was drawn out in the shape of a cone, with a small opening at the apex. A small filter placed in the cone kept any of the substance from passing through the opening. The tube was suspended in a small flask, and this stoppered with a cork through which a long glass tube passed. The whole was placed in a water bath. ether ($\frac{1}{2}$ oz.) put in the outer tube, and heat applied to the water bath until the temperature of the water boiled the ether. This operation was continued for half an hour, the percolate transferred to small weighed beaker, ether evaporated and the beaker and its contents dried at 100° C., and then weighed.

Tannin.—One gram of the pulverized seed was digested with hot water for several hours, and the tannin estimated by a standard solution of gelatine.

Composition of Sorghum Seed—Orange.—

Sugar	0.56
Starch	63.09
Fiber	6.35
Water	12.51
Ash	0.64
Albuminoids	7.35
Oil	3.08
Tannin	5.42
Total	99.00

EXPERIMENTS IN SUGAR MAKING.—1880.

The grinding of cane and the evaporation of the juice began on the 18th of September. It was the intention to begin working up the Early Amber as soon as possible after it had reached its maximum per cent. of cane sugar, and thus have it finished by the time the Orange was ready to harvest, leaving a small portion for subsequent experiments. Owing to the delay in the arrival of machinery, the work was not begun until the above date.

The Early Amber had been ripe for over two weeks, and was lying prostrate from the effects of a storm. The Orange was ripe. The object of these investigations was to see whether any method of manufacture of the juice into syrup could be depended upon to insure the subsequent crystalization of the sugar.

These investigations were undertaken with a view to the simplicity of machinery used and to the economical manufacture of the syrup, so that they could be of practical use to the farmer, should any of the experiments prove successful.

The apparatus used for crushing and pressing the cane, was a two-horse Victor mill, with three upright rollers. The juice was evaporated in Cook's evaporator, with furnace attached, and of the size recommended for use with a two horse crusher.

The remaining apparatus consisted of barrels, tubs, pails, etc.

An attempt was made to heat the juice for skimming and clarification after it had been treated by chemicals, in the pan of a steam boiler of the form used by farmers to cook food for cattle. This boiler was found unfit for the purpose, as the temperature of the juice could not be raised in it above 108° C. A small pan was made, similar in construction to a Cook's evaporator, but furnished with a double bottom. The steam space in the bottom was about two inches high, and was connected with one of the boilers in the Chemical Laboratory. The object was to test the feasibility of evaporating the juice by steam under pressure with shallow pans.

In the experiments which follow, the juice was either evaporated directly after it came from the mill, *i. e.*, without the use of re-agents, or after it had been submitted to clarifying processes. In the first, the juice is designated in the experiment as *not clarified*, in the second, as clarified, defecated, or *neutralized*.

THE EXPERIMENTS.

1. *Early Amber.*—September 18. Cane, very ripe and down ; juice, *not clarified*,—evaporated to a sirup which upon cooling weighed 11 lbs. to the gallon. It was of a light color and had a distinct sorghum taste. Stalks, stripped and topped, yielded 48 per cent. of juice, having a specific gravity of 1.066. The sugar, not crystallized.

2. *Early Amber.*—September 20. *Juice defecated.* As the juice was brought from the mill, milk of lime was added, little at a time, until a piece of red litmus paper would change to purple when dipped into the juice. Then a solution of tannic acid and finally gelatine was added. The juice was then boiled and well skimmed, and concentrated to sirup. The sirup was scorched and had a taste of extract of licorice. A small portion of the sirup evaporated to almost candy, was readily crystallized.

3. *Early Amber.*—September 21. Juice not clarified. The evaporation was continued until the sirup upon cooling weighed 11 lbs. The sugar did not crystallize.

4. *Early Amber.*—September 22. Juice made alkaline with lime, and then neutralized with sulphate of alumina. Concentrated to a sirup that weighed when cooled between 11 and 11½ lbs.: sugar crystallized.

Before expressing the juice for this experiment the rollers were moved closer together and the cane crushed so much that the bagasse as it came out fell in pieces. 51 per cent. of juice was obtained with a specific gravity of 1.068. One row of cane (0.037 acres) was taken for this experiment, producing 23 gallons juice from which was made 3.17 gallons sirup, weighing 11¾ lbs. per gallon. Calculating from this data, an acre of the early amber would yield 624.2 gallons of juice, or 86.1 gallons of sirup.

5. *Orange.*—September 23. Juice neutralized with milk of lime; afterwards tannin and gelatine added; evaporated to a syrup of 12 lbs. to the gallon; syrup dark. The sugar commenced crystallizing in a few days. Three weeks afterwards the sugar was separated from the sirup by a centrifugal separator. Sugar, brown.

In this experiment, 360 lbs. of topped and stripped stalks were used; producing 155 lbs. of juice (43 per cent.); 28 lbs. sirup (7.78 per cent. of the stalks and 18.04 per cent. of the juice); 13½ lbs. sugar (3.8 per cent. of stalks, 8.87 per cent. of juice, 49.1 per cent. sirup.)

One row, .0398 acres, yielded 30 lbs. juice. Calculating the yield of an acre from these data, we have 754 gallons juice, 120.6 gallons, or 1,447.2 lbs. sirup, and 710.67 lbs. sugar.

6. *Orange.*—Sept. 24. Juice neutralized with lime, and a few drops of tannin added to every 10 gallons juice; then ⅛ oz. gelatin, and afterwards a little sulphate of alumina. Juice evaporated to a sirup of 11 lbs. to the gallon; color, very light. Sugar began crystallizing after standing two days.

7. *Orange*—Sept. 27. Juice neutralized with lime, and concentrated to a sirup of 11 to 12 lbs. per gallon. Sugar readily crystallized.

8. *Orange.*—Sept. 27. Juice neutralized with milk of lime; *sulphurous* acid was added to combine with any lime remainiug uncombined in the juice. The sugar began crystallizing as the sirup was cold.

9. *Orange.*—Oct. 1. Juice defecated with lime and sulphate of alumina. Sugar began crystallizing after three days. In this experiment stripped and topped stalks were used; yielding 54.2 per cent. of juice; specific gravity, 1.076.

10. *Orange.*—Oct. 1. Juice evaporated without defecation. The

sirup, after standing about five weeks, had but few crystals of sugar. In a subsequent analysis of this sirup (see analysis of sirup, No. 4), there was found to be 38.9 per cent. of cane sugar, and 26.91 per cent. of grape sugar.

11. *Orange.*—Juice not defecated; evaporated to a sirup of 12 lbs. to the gallon. The sugar has not crystallized.

12. *Amber.*—Juice defecated with lime and sulphate of alumina. The juice was quite acid as it came from the mill. Sirup black. Sugar crystallized.

Finding that some of the sirup whose juice had not been defecated, did not crystallize, it was thought that, perhaps, a farther concentration would cause the sugar to crystallize. For this purpose the sirup produced in experiment No. 3 was selected. In the early part of November it was further concentrated in the steam evaporator, but this had no effect upon the crystallization of the sugar.

Finding that the concentration of the sirup did not cause the sugar to crystallize, an analysis of several of the sirups was undertaken, in order to investigate this subject more thoroughly. The following sirups were selected to be analyzed:

No. 1. *Early Amber.*—Sirup taken from that made in experiment No. 3.

No 2. Sirup of No. 1 subjected to further concentration.

No. 3. *Orange.*—Sirup of experiment No. 9, with the crystallized sugar taken out by the centrifugal separator.

No. 4. *Orange.—Obtained from the sirup of experiment No.* 10.—The following were the results obtained:

COMPOSITION OF SORGHUM SIRUPS.

Number.	Cane Sugar.	Grape Sugar	Gum.	Water.	Ash.	Total.
No. 1	47.22	14.70	6.80	29.4	1.97	100.1
No. 2	45.62	20 00	10.51	20.39	3.78	100.3
No. 3	35.63	26.82	6.75	28.67	1.40	99.27
No. 4	38.9	26.91	7.80	24.04	1.75	96.40

The cause of the large per cent. of ash shown by No. 2 was undoubtedly the lime added to neutralize the sirup before the second concentration.

From the proximate analysis of the cane, it appears that one acre of sorghum produces 2,559 pounds of cane sugar. Of this amount we obtained 710 pounds in the form of good brown sugar, and 265 pounds were left in the 737 pounds of molasses drained from the sugar. Hence, sixty-two per cent. of the total amount of sugar was lost or changed during the process of manufacture. This shows that the method of manufacture in general use is very imperfect.

EXPERIMENTS IN SUGAR MAKING IN 1881.

Last year a large number of experiments were made in order to determine the means by which the cane sugar could be made to crystalize.

This object was much more readily attained than we at first expected, and consequently we selected from those experiments the one which was most simple and most likely to be practicable when operating on a large scale. In perfecting this our attention was given to the production of sugar and sirup which should be free from the objectionable sorghum taste and odor. In this we succeeded perfectly. Sorghum juice in its normal condition is acid. The conversion of cane sugar into grape sugar by boiling a solution of the same with a strong acid, as sulphuric or hydrochloric, has long been known to chemists. All other acids, even the weak organic acids contained in sorghum juice, act in a similar manner. Hence it will readily appear, why in the ordinary manner of making sorghum sirup, so little of the cane sugar originally contained in the juice can be made to crystallize. A great deal of the cane sugar is converted into grape sugar during the processes of defecation and evaporation, and what remains unchanged is prevented from granulating by the undue proportion of grape sugar produced. To avoid this loss of cane sugar we neutralize the juice when cold with calcium carbonate or milk of lime or both. This part of the process requires skill and care, as the subsequent defecation of the juice depends upon it. After thus neutralizing the juice it is heated to boiling and thoroughly defecated. It is then passed through bone-back filters and finally evaporated to crystallization. The sugar and molasses obtained by this process are unobjectionable in regard to color and taste.

Exp. 1—August 22, 1881. The cane selected for this experiment was grown on land which had previously been used as a barn-yard, the same as in analyses, Nos. 8 and 14. The seed was nearly ripe and the cane very thrifty.

Wt. of cane crushed	156.00 lbs.
Wt. of juice obtained	687.50 lbs.
Per cent of juice	43.40

The juice was carefully neutralized with milk of lime, and brought to the boiling point in the defecating pan. A very heavy green scum rose, and this being removed the juice was seen to be full of a green light flocculent precipitate which did not subsequently rise to the top, in any considerable quantity. The juice was now drawn off into tubs where it was allowed to repose twelve hours. At the end of this time only about one-half of the juice could be drawn off clear, the precipitate being still suspended in the remainder. It was found impossible to filter this portion and it was therefore thrown away. The clear juice after being passed through bone-black was evaporated in a copper finishing pan to the crystallizing point. The melada had a very unpleasant saltish taste owing to the presence of salts of ammonia. The sugar crystallized very readily and although it looked well it still retained somewhat of this saltish taste after being separated from the molasses. Unquestionably this excessive amount of albuminoids—the green scum and suspended precipitate—was taken up by the plant from the nitrogenous elements of the manure, and the saltish taste was due to ammonium salts which came from the same source.

Manure therefore not only has a deleterious effect upon the development of sugar in cane, but it also prevents the thorough defecation of the juice which is necessary to the manufacture of sugar.

Experiment 2—Aug. 25. Cane same as that of which analyses Nos. 15 and 16 were made. Size of field 3-16 of an acre.

CALCULATIONS FOR ONE ACRE.

	Pounds.
Stripped cane with tops	18535.3
Stripped cane without tops	15765.9
Weight of juice obtained	6545.6
Per cent. of juice of stripped and topped cane	41.52
Weight of melada from juice	1298.7
" " " bagasse	253.9
Total weight of melada	1552.6
Weight of sugar from juice	504.0
" " " bagasse	104.7
Total weight of sugar	608.7
Weight of molasses from juice	794.7
" " " bagasse	149.2
Total weight of molasses	943.9

Calculations for one ton of topped and stripped cane:

Weight of juice	830.4
" sugar	77.2
" molasses	119.7

To obtain the sugar from the bagasse it was packed in large barrels as it left the mill and was exhausted with water. The percolate thus obtained was treated like juice.

Experiment No. 3—Sept. 17. Early amber. Obtained from University farm. Volunteer growth among the corn. Seed ripe. Cane mostly blown down.

	Pounds.
Weight of stripped and topped cane	1440
Weight of juice	637
Per cent. of juice	44.2
Weight of melada obtained	145.8

Experiment No. 4. Early amber, grown upon University farm:

	Pounds.
Weight of stripped and topped cane	1661.0
" " juice obtained	603.5
Per cent. of juice	36.33
Weight of melada from juice	95.5
" " " bagasse	13.5
Sugar from juice	41.5
" " bagasse	6.0
Molasses from juice	54.0
" " bagasse	7.5

In the last two experiments the cane was poorly developed, and full of suckers, and consequently poorly adapted for the production of sugar.

GLUCOSE FROM SORGHUM SEED.

Our experiments have shown, that as good glucose can be made from the seed of sorghum as from any other starchy substance. The yield of glucose or grape sugar is three-fourths or more of the weight of seed employed. The tannin does not interfere, as it is converted into glucose by the same means which are used to convert the starch, namely boiling with dilute acids.

RECEIPTS AND EXPENSES OF ONE ACRE OF SORGHUM.

On the basis of the results actually obtained as described in the foregoing pages, we have calculated the receipts, and from the best data at hand the expenses, for one acre of sorghum.

BALANCE SHEET.

RECEIPTS FROM SUGAR AND MOLASSES.

600 lbs. sugar @ 7 cts	$42.00		
85 gallons molasses	34.00	$76.00	

EXPENSES.

Cultivating one acre	$10.00		
Stripping and cutting	2.50		
Hauling	6.00		
Four days labor	6.00		
Fuel	1.00		
Barrels	4.00		
Freight and drayage	8.00	$37.50	
Net profit on sugar and molasses		$38.50	$38.50

RECEIPTS FROM GLUCOSE.

1250 lbs. glucose @ 2 cts		$25.00	

EXPENSES.

Gathering seed	$2.00		
Fuel	1.50		
Labor	1.00		
Barrels	4.00	$9.50	
Net profit on glucose		$15.50	$15.50
Total net profit on one acre of sorghum			$54.00

GENERAL CONCLUSIONS.

1. Seed should be planted as early as possible.

2. The proper time to begin cutting the cane for making sugar is when the seed is in the hardening dough.

3. The cane should be worked up as soon as possible after cutting. Cane which is cut in the afternoon or evening may safely be worked up the following morning.

4. The manufacture of sugar can be conducted properly only with improved apparatus and on a scale which would justify the erection of steam sugar works, with vacuum pans, steam defecators and evaporators, and the employment of a competent chemist to superintend the business. The same is true for the manufacture of glucose from the seed. Our experiments were made with the ordinary apparatus used in manufacturing sorghum sirup, and any person, who desired to work on a small scale, could use the methods with good results, provided he had acquired the necessary skill in neutraliziug and defecating the juice and in the treatment of bone-black filters. The manufacture of glucose on a small scale is entirely out of the question. Five hundred to a thousand acres of sorghum would be sufficient to justify the erection of steam sugar works and this amount could easily be raised in almost any community within a radius of one or two miles from the works.

THE SUGAR CANE.

REGISTERED FOR TRANSMISSION ABROAD.

No. 6. JANUARY 1, 1870. Vol. II.

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TO OUR SUBSCRIBERS.

FIVE MONTHS have clapsed since the publication of the first Number of "*The Sugar Cane*," and its success is now fully assured; the number of subscribers already obtained has far exceeded our expectations, and new names are received daily. To all who have aided us in our undertaking, whether subscribers or contributors, we tender our thanks, as well as to the conductors of numerous periodicals by whom our Magazine has been favourably noticed. Though the financial condition of "*The Sugar Cane*" is thus satisfactory, it is to be regretted that we have not been favoured with a larger number of communications from those engaged in cane sugar production in various places. Whilst articles of a technological character come to hand almost in profusion, we have been somewhat disappointed in having received so few of a practical character relating especially to cane cultivation. We appeal to our friends in all parts of the world to aid us by forwarding information of this nature for discussion in our pages, and we may remind them that nothing is so valuable as the carefully verified results of individual experience. On the part of the proprietors of this Magazine, nothing will be wanting to make it increasingly valuable to all classes of its readers, and especially to those who are directly interested in the production of cane sugar.

As it is generally much more convenient to commence a new volume of a periodical with the first month of each year, we have decided that the present Number shall be the first of Volume Second, and, accordingly, have supplied a title-page and complete index for the First Volume.

ON THE CHEMISTRY OF SUGAR REFINING.

By Dr. Wallace, F.R.S.E., Glasgow.

A Discourse delivered before the Fellows of the Chemical Society, February 4, 1869, and Revised by the Author for Publication in "*The Sugar Cane.*"

(*Continued from page* 267.)

Filtration through Charcoal.

After this rather lengthy digression, we return to the process of sugar refining as it actually exists. After being made clear and transparent by passing through the bag filters, the liquor is run into iron tanks or cisterns filled with animal charcoal, where it is allowed to settle for several hours, after which it is slowly drawn off below, while more of the dark coloured liquor is run on to the top, so as to keep the cistern full. As this goes on, the liquor, which comes away at first perfectly colourless, becomes after a time distinctly yellow, and the sugar solution is replaced by the syrup from a previous refine; and lastly, this is washed out with hot water until no appreciable trace of sugar can be found in the washings; then the charcoal is further washed with a copious volume of boiling water, next with some cold water, and afterwards drained, removed from the cisterns, and taken to the kilns to be reburned. Such, in few words, is the decolorizing process, which, however, I must now describe in greater detail.

The cisterns are of various forms and sizes; some are square and shallow, some of great depth, 40 to 60 feet, and so on; but the kind universally employed in the Clyde refineries are circular, and of no great depth, being generally about 9 feet diameter and 16 feet deep, and capable of containing from 20 to 25 tons of charcoal, according to its density. The cisterns are covered on the top, and are constructed to bear the pressure of a considerable column of water, or liquor, which may be applied when necessary, to cause a more rapid filtration. The quantity of charcoal to a given weight of sugar varies exceedingly. Where water is scarce or dear, coals dear, and, above all, where the charcoal has to be sent out of town to be reburned, the quantity of char is necessarily reduced as far as possible, but in other circumstances the proportion should not be less than 25 cwt. of char to a ton of sugar. The size or "grist" of the charcoal must depend to some extent on the shape and size of the cisterns; but in all cases where it is possible to use it, a small size, such as would pass through a sieve of 20 meshes to the inch, but would be retained by one of 30 meshes, should be chosen. Theoretically, the smaller the grist the better, the finest dust being the best of all; but practically, the char must have a sufficient size to permit the liquor to pass through it in a reasonable time. Then as to the quality of the charcoal, it would occupy an entire lecture to go fully into that department. The whole subject is fully discussed in a lecture which I delivered last year in Glasgow, and which will be found in the Proceedings of the Philosophical Society of Glasgow (Vol. VI. part 4), also in abstract in the *Chemical News*. On the present occasion I can only refer to some points connected with this most important subject. Animal charcoal, when new, consists of carbon, calcic phosphate and carbonate, and minute quantities of some other substances; the composition is a little variable, but the following results of analysis of three varieties will convey a good idea of its usual constituents, A being made from ordinary bones, collected in this country; B, from South American shank bones, and C, from what are called camp bones, which are frequently buried for some years before they are collected :—

Dry.	A.	B.	C.
Carbon, nitrogenous	9·71	7·64	10·37
Calcic phosphate, &c. ..	80·48	84·05	78·70
Calcic carbonate........	8·82	7·61	8·05
Calcic sulphate	·34	·20	·53
Alkaline salts..........	·30	·25	·58
Ferric oxide	·12	·15	·21
Silicious matters	·23	·10	1·56
	100·00	100·00	100·00
Cubic feet per ton (dry)	51	49	47

The above analyses represent the charcoal as being dry, in order that they may be compared with one another; but practically the article is always sold with about 10 per cent. of water.

The so-called carbon in animal charcoal is not by any means pure, for it contains a very notable amount of nitrogen, and a small proportion of hydrogen, the quantities of both of these elements depending upon the degree of heat to which the charcoal has been exposed in the process of manufacture. Generally the quantity of nitrogen is about one-tenth part of the total carbonaceous matter, but sometimes I have found it considerably more. The proportion of hydrogen in well-burnt animal charcoal is exceedingly minute, being in one particular case (new) only ·034 per cent. Old charcoal which has been frequently used in refining, and reburned, contains less nitrogen, and the proportion appears continually to decrease. I have found it as low as ·3 per cent., and as the charcoal which gave this amount was not excessively old, I have no doubt it may be reduced even further. I believe that the nitrogen is an important and essential constituent of animal charcoal, and it is certain that no description of charcoal which does not contain an appreciable quantity of nitrogen is a good decolorizing agent. Wood charcoal, for instance, although eminently porous, and an excellent absorbent of gases, is a very poor decolorizing agent, and is practically useless. Red-hot animal charcoal quenched with water evolves ammonia, and I believe that the practice of cooling charcoal in this way pursued by some refiners is a highly injurious one.

New charcoal always contains traces of ammonia, but the amount is extremely minute, being in a particular case only ·011 per cent. The effect of this minute quantity, and of traces of sulphide of ammonium, is readily seen in the sugar run over new charcoal, which should never be used until after it has been well washed and reburned. New charcoal also contains invariably a minute quantity of sulphide of calcium, and gives off the odour of hydric sulphide when treated with an acid, and even when moistened with water. In a particular case a sample of new charcoal gave ·08 per cent. of hydric sulphide when treated with an acid. Charcoal, both new and old, retains appreciable quantities of gases which escape when cisterns containing it are filled with liquor, and these gases frequently explode when a light is brought near the top of the cistern.

In a sugar-house the charcoal is usually burned every fourth or fifth day, and is thus reburned from seventy to ninety times in a year. Old charcoal has not the same chemical composition as new. The carbon almost invariably increases, and if the kilns are perfectly tight, ought to increase, so that the pores are gradually filled up with the deposit of carbon, arising from the carbonizing of the vegetable matter extracted from the raw sugar which it has been employed to purify. This deposit of carbon is a very great evil in sugar refining, and should be prevented, as far as possible, by washing the charcoal with boiling water before reburning. In some refineries the proportion of carbon does not increase, and in others it speedily diminishes, so that it sometimes does not exceed 2 or 3 per cent. When this decrease takes place, it arises either from the admission of air to the charcoal while hot, or from excessive burning, which causes a reaction to take place between the carbon and the elements of water, resulting in the formation of carbonic gas and marsh gas. But if the kilns and cooling boxes are tight, and the heat not excessive, the carbon will inevitably increase rapidly, unless we take the precaution of washing out of the charcoal, before reburning, nearly all the organic matters absorbed from the sugar liquor.

Extensive washing has also a most beneficial influence in removing mineral salts absorbed from the raw sugar. In all raw sugars a certain proportion of mineral salts is found, varying in ordinary cane sugars from ½ to 1 per cent., in syrup sugars from 1 to 2 per cent., and in beet sugars, such as are used by the British refiners, from 1 to 7 per cent. The highly soluble salts, such as those of potassium, have no effect upon the charcoal, and only annoy the refiner by accumulating in the syrups; but calcic sulphate, a salt only slightly soluble in water, is readily absorbed by charcoal, and can only be removed by extensive washing. It is rather a singular fact, that so long as the sugar liquor is strong, the sulphate is absorbed and retained; but whenever the washing begins, it comes away in the washings, so that it is no uncommon thing, in boiling down weak char washings, to obtain a plentiful crop, not of sugar, but of gypsum. When the water is hard, and contains much calcic sulphate, the proper washing of charcoal becomes almost, if not quite, an impossibility; and I have myself examined charcoal which contained 2½ per cent. of that compound. In beet factories where lime is freely used in clarifying the juice, the pores of the charcoal soon become choked with calcic carbonate, rendering it useless, unless the compound is removed by treatment with an acid.

But charcoal becomes old and useless from another cause; it gradually shrinks in volume, and the pores must become either lessened, or altogether obliterated. The space occupied by a ton of new charcoal, when dry, is usually about 50 cubic feet; but after being a few months in use it is reduced to 40, and so it goes on shrinking, until it reaches 28 cubic feet, which is the densest charcoal out of about 400 samples that I have tested. Now, this does not arise from an actual increase in the density of the charcoal. I have tried the specific gravity of old and new charcoal, and have found the difference very slight indeed. Thus, new charcoal, occupying 50·6 cubic feet per ton, had a gravity of 2·822, while the old, occupying only 35 cubic feet, had a gravity of 2·857. The fact is, that the heat to which the char is subjected produces a semi-fusion of the calcic phosphate, which is its most abundant constituent, and causes a shrinking in the bulk of the particles. The following simple experiment serves to illustrate this point:—A quantity of new charcoal, measuring 48 cubic feet per ton, was exposed, in a covered crucible, to a rather strong heat for an hour, after which it had contracted to 43·2 cubic feet, after two hours more to 40·8 cubic feet, after other four hours it measured 38, and with still four hours longer of a strong heat, 35·5 cubic feet—thus losing in eleven hours as much of its porousness as it would by being worked in a sugar-house for two years. It is well known to chemists that calcic phosphate is fusible at a high heat, but the temperature of a charcoal kiln is sufficient to produce only agglutination. New charcoal burnt white has the appearance of bits of chalk, but old charcoal has the texture of porcelain or flint. The quantity of liquid capable of being retained by the two kinds is also remarkable. If a funnel is filled with good new charcoal, perfectly dry, and water poured on it as long as it is retained, it will be found to hold in its pores from 80 to 100 per cent., while old charcoal retains from 30 to 45 per cent. according to its quality. Again, dry new charcoal does not become perceptibly wet, unless at least 20 per cent of water is added to it, while old charcoal is made wet with 5 per cent.

All these considerations point to the necessity of renewing the charcoal very frequently, in order that it may act efficiently. It is not enough merely to replace the dust that is sifted out occasionally, and to make up by the addition of new char for the shrinkage in volume that is constantly taking place. If proper work is to be done, and the charcoal maintained in a state of real efficiency, a portion of the entire char (not the dust only) should be set aside from time to time, and replaced by new material at the rate of 50 per cent. per annum, and the addition should be made constantly—one, two, or three bags of new charcoal in every cistern, according to its capacity.

As regards the proper quantity of charcoal to use, per ton of sugar, that depends a good deal upon the kind of sugar used, and upon the quality of the charcoal; but the smaller the quantity of charcoal the better, for the use of a large quantity entails a loss of sugar and the production of an extra proportion of weak and impure washings. For a ton of sugar 25 cwt. of charcoal is amply sufficient if the quality is good, and if fine sugars are used an equal weight is enough. It is a mistake to suppose that a large quantity of bad or exhausted charcoal will serve the same purpose as a moderate amount of good charcoal. Not only does it occupy more space, and so limit the production of refined sugar, but it does not, in any quantity, do the work so well, besides producing an overwhelming amount of "sweet water," or charcoal washings. I have found that it is impossible, on a practical scale, to wash out all the sugar from charcoal, so as to make the washings worth boiling down, and that for every 100 parts of charcoal there is a loss of ·75 of sugar. If, therefore, an equal weight of charcoal is used, the loss of sugar will be ·75 per cent., while if two tons of charcoal are used for each ton of sugar, the loss will be 1½ per cent. from this source alone.

I have selected a few analyses of specimens of old or used charcoal, which will convey an idea of the variety to be found in different sugar-houses throughout the country.

	D.	E.	F.	G.	H.	I.	K.	L.	M.
Carbon, nitrogenous	9·74	10·60	12·86	19·64	7·42	10·64	5·82	17·28	2·56
Calcic phosphate ..	82·80	83·20	81·80	73·20	87·08	80·56	77·26	79·56	90·73
Calcic carbonate ..	5·92	4·15	2·92	3·18	1·92	4·52	14·66	1·05	3·50
Calcic sulphate	·67	·64	·42	1·12	·95	2·24	1·03	·59	1·10
Ferric oxide	·33	·55	·67	·66	·85	·72	·21	·69	1·17
Silicious matters ..	·54	·86	1·33	2·20	1·78	1·32	1·02	·83	·94
Cubic feet per ton..	44	39	36	32	29	35	40	34	35

D is first-class charcoal; E is of excellent quality; F is of fair average quality; G is pretty old and very much glazed; H is very old and overburned; I has been used in a sugar-house where hard water is employed; K has been used in a continental beet factory; L has been soured in the process of washing; and M has been exposed to the air while cooling.

The power which charcoal is capable of exerting in removing colouring matter from solutions is truly astonishing. A very good lecture-room experiment consists in pouring into a funnel, filled with good animal charcoal, an aqueous solution of cochineal, when it comes through perfectly colourless, and its presence in the charcoal in an unaltered form may be illustrated by boiling the charcoal with alcohol, when it gives up the colouring matter to that liquid. Port wine may be used for the same purpose, and with a like result. Charcoal has also the power of absorbing vegetable albumin, gum, oxide of iron, calcic carbonate and hydrate, and calcic sulphate. In sugar we have vegetable albumin, extractive matters, and invariably some salt of calcium, and all these, as well as the colouring matter, are removed by the charcoal; and not only so, but their removal is important and essential, so that if we could practically bleach sugar by ozone, chlorine, sulphurous gas, or any other chemical agent, we should still require to use charcoal to purify the sugar.

The active ingredient in animal charcoal is unquestionably the nitrogenous carbon, for if the charcoal is burned perfectly white, not only on the outside of the grains, but to the very centre of each particle, it no longer retains the slightest trace of decolorizing power. But it is quite evident that the carbon owes its extraordinary powers to its extreme porosity, the carbon being infinitely comminuted and kept asunder by admixture with ten times its weight of calcic phosphate. The dark brown solution of raw sugar comes away at first perfectly colourless; after a time the pores of the charcoal begin to get saturated, and the liquor gradually becomes yellow, and even brown, if the process is continued long enough. The sugar refiner takes care to economize his charcoal by passing through it first a fine quality of raw sugar, afterwards an inferior sort, and lastly, syrups from the drainage of previous refines.

The calcic carbonate in charcoal is very useful in neutralizing the minute quantity of acid present in almost all raw sugars, and also the acids always formed during the washing of the charcoal by a process of fermentation which it is very difficult to prevent. Charcoal deprived of all, or nearly all, its calcic carbonate is very objectionable, and is sure to give rise to sour liquors and the occurrence of iron in the syrups. When the water used for dissolving the sugar and for washing the charcoal is very soft, the calcic carbonate gradually decreases, until, in pretty old char, it is reduced to 1½ per cent., and even in extreme cases disappears entirely. On the other hand, when very hard water is used, the calcic carbonate either decreases very slightly, or it increases, and sometimes to an alarming extent; and in beet factories on the continent, where lime is freely added to the juice, the evil is a very serious one. In this case it closes up the pores, and many expedients have been adopted for the purpose of getting rid of it. This is done either by washing with 1 or 2 per cent. of hydrōchloric acid diluted with a sufficient quantity of water to saturate the char, or better, by Mr. Beanes' process, which consists in impregnating the burnt charcoal with perfectly dry hydrochloric gas until it is saturated, then exposing it to the air until the excess of the gas escapes, and lastly, washing with water and burning. In beet factories, and, in some particular circumstances, in refineries also, when the liquors are slightly alkaline, the process is attended with the best results, but I have always objected to the use of acid in refineries using soft water, for there the calcic carbonate, instead of being in excess, is barely sufficient to neutralize the minute quantity of acid in the raw sugar. That animal charcoal treated with an acid gives a whiter liquor than it would otherwise do is easily demonstrated; but, on the other hand, it appears from my own experiments and those of others, that it is impossible to get rid, by mere washing, of every trace of acid; and the consequence to be feared is, that the sugar in the liquor will be, to some extent, converted into fruit sugar during the process of boiling down, that the char washings will be very sour, and the syrups contaminated with iron. In other words, I believe that in a refinery working under ordinary circumstances, less syrup is produced than would obtain if the charcoal were treated with hydrochloric acid, while in the latter case the colour of the sugar produced would be superior. It may be interesting to mention that while dry hydrochloric gas, passed over dry calcic carbonate, does not give rise to any action whatever, the dry gas passed over absolutely dry charcoal containing calcic carbonate determines the complete decomposition of the latter, especially if the charcoal is warm. Beanes' process, and others of a similar nature, may be applied with advantage to new charcoal for the purpose of bringing it at once into efficient working condition. New charcoal contains traces of ammonia and sulphide of ammonium, and also some free lime, besides an excessive quantity of calcic carbonate; and although the ammonia is removed, and the free lime carbonated by the processes of washing and reburning, to which it ought always to be subjected before being employed in sugar refining, yet the excess of calcic carbonate makes the liquors very yellow, and it is usually five or six weeks before the charcoal is in first-rate condition. When, however, the new charcoal is added in small proportion to the old, there is no danger of any harm resulting, but, on the contrary, an immediate advantage is observed.

The oxidizing power of charcoal is well known to chemists, and although this property is useful in purifying water and in deodorising, yet in sugar refineries it is the cause of much mischief. When the char cisterns of a refinery are to be washed off, hot water is run on, while the heavier syrup descends, and is drawn off below. But the two liquids commingle to some extent, and a weak solution of sugar is formed which is exceedingly liable to fermentation. The free oxygen in the washing water, under the influence of the charcoal, appears to act upon the vegetable albumin which the charcoal has extracted from the sugar, converting it into a ferment which quickly changes the sugar into lactic acid, and this acid dissolves from the charcoal lime and traces of iron. The consequence is that the char washings are sour and putrid, and highly charged with salts of calcium, besides which they frequently smell perceptibly of hydric sulphide. The ordinary way of getting rid of these washings is to use them for dissolving fresh sugar, but no greater mistake in sugar refining than this could be made.

As regards the temperature best adapted for the action of charcoal on sugar, experience has shown that the liquor in the blow-up pans should be run off at 180° Faht., the char cisterns should have a temperature of about 155°, and never below 150°, and the water used for washing should be absolutely boiling. The quantity of water employed in the process of refining is, say for 100 tons of sugar, something like this:— for dissolving, 50 tons; for washing to produce sweet washings to be afterwards boiled down or used for dissolving, 40 tons; for washing the charcoal to purify it further, 125 tons—in all, 215 tons, or nearly 50,000 gallons. I consider this the minimum quantity; an additional amount of washing is invariably attended with increased excellence in the quality of sugar turned out.

Revivifying of the Charcoal.

The reburning of charcoal, in order to restore to it the power of absorbing colouring matter and other impurities, is perhaps the most important process in sugar refining. The object to be attained is to carbonize the organic matter extracted from the raw sugar, so far as it has not been removed by washing. The process should be economical as regards fuel; it should allow of the complete carbonization of the organic matters; it should permit of the ready escape of the gases and vapours produced; and it should expose the charcoal for only the smallest possible length of time to the heat required for carbonization, so as to avoid the contraction of the pores of the charcoal, besides other evils that result from overburning. There are two distinct kinds of reburners: those in which upright pipes are used, and those which consist of horizontal revolving cylinders.

The kiln in general use consists of a series of upright cast-iron pipes, arranged in six rows of about ten pipes each row, three rows being placed on each side of the furnace. The flame of the furnace plays directly upon the pipes, and the products of combustion are conducted away from the sides of the kiln. The wet char, as it comes from the cisterns, is placed upon the top of the kiln, and sinks gradually down as the burnt char in the pipes is allowed to fall into the cooling boxes below. These consist of sheet-iron vessels, the same length as the row of pipes to which they are attached, about six or eight feet deep, and an inch or three-quarters of an inch wide, and cooled simply by contact with the atmosphere. The cooled charcoal is drawn from the cooling boxes every twenty minutes, in such proportion that it is about six or eight hours in the pipes altogether. The time given should depend upon the heat of the kilns, and different quantities should be drawn from each row of pipes according to the amount of heat they receive from the fire. Thus, if there are three rows of pipes, the one nearest the fire should be emptied in about 5 hours, that in the middle in 7½ hours, and the back row in 10 hours. These kilns, although tolerably economical as regards fuel, are open to many objections, not the least of which is that the wet charcoal above prevents the free escape of the gases and vapour evolved from the carbonizing and drying charcoal. Of the heat consumed in the kiln, four-fifths are absorbed in drying, and it is a great mistake not to dry the charcoal, wholly or partially, before putting it into the kilns. I cannot occupy more time with further details of the various mechanical arrangements which have been adopted by various sugar refiners, nor with the description of the various forms of revolving cylinder-kilns, information about which will be found in my paper on charcoal, previously referred to.

When the charcoal is sufficiently cold, it is again placed in the cisterns, and the whole process is repeated.

Evaporation of the Liquor.

The next process in sugar refining is the boiling down of the decolorized liquor, so as to recover the sugar in a crystalline form. This, as is well known, is effected by means of a vacuum pan, in which the vapour that is formed is condensed by jets of water, and the vacuum is maintained by means of an air-pump. A pan of good size is 10 or 12 feet in diameter, and may hold about 20 tons of sugar and syrup. The boiling down occupies usually about two or three hours; the extent of vacuum averages, in a well-made pan, about 28 inches, and the temperature is usually 120° Faht. at the beginning of the boiling, and about 130° at the end of the process. The improvements introduced of late years into the vacuum pan consist in increasing the extent of heating surface, and the quantity of water injected into the condenser, and in enlarging the neck of the pan to 18 inches, or even more, so as to permit of the free escape of the vapour into the condenser. The operation commences by running into the pan a quantity of liquor sufficient to cover the first coil of steam pipe or "worm," when the steam is turned on and the boiling commences. After a time more liquor is run in, and so on, a little at a time, until the pan is full, the different tiers of worm being supplied with steam as soon as they are covered. At the very first the liquor is boiled strong enough to form a "grain," consisting of almost microscopic crystals of sugar, and these increase in size as the boiling proceeds, until at the finish they are as large as may be desired. It requires a considerable amount of training and skill to boil sugar so that the grain may be gradually built up. What is called false grain consists of a mass of minute crystals collected into grains, and although in some cases this kind of compound crystal results from the carelessness or want of skill of the boiler; in other instances it is made intentionally, so as to give the resulting sugar a whiter appearance, and to enable it to hold more syrup.

When very large and distinct crystals are desired, such as are made in Bristol and Glasgow, a modified arrangement is adopted. The liquor is boiled more slowly and at a higher temperature, and when the pan is full the whole contents are not drawn off, but only a half; and this is repeated several times, the crystals becoming larger every time. The large crystals are much prized on account of their beauty and purity, but they have the disadvantage of being troublesome to dissolve, while the manufacture of them necessitates the exposure of the syrup with which they are mixed for a long time to a rather high temperature (about 160°), causing the conversion of a considerable portion of sugar into the uncrystallizable form, and also darkening the colour of the syrup. And here I would give a word of advice to refiners, who all insist that in order to obtain large crystals a high temperature must necessarily be employed. I believe this to be a mistake. If sugar requires a high temperature to form large crystals, it must be different from all other crystalline bodies; and besides, sugar candy is formed at a low degree of heat, and consists of larger and more distinct crystals than ever were formed in a vacuum pan. Large crystals must be formed slowly, and the degree of heat is, I believe, a matter of indifference. Strange to say, I have not succeeded in inducing any refiner to boil slowly and at a low temperature. They all say that it cannot be done, and so the matter rests. The mistake they make is, that they regulate the rapidity of boiling, not by the quantity of steam admitted to the worm, but by the quantity of injection water, so that, when the latter is diminished, the extent of vacuum is lessened, and the temperature necessarily rises, while the steam, not escaping readily, retards the process of evaporation. If, on the other hand, the maximum quantity of injection water were maintained, and the amount of steam diminished, the boiling would be as slow as might be desired, while the loss to the refiner by exposing the syrup to a high temperature would be avoided.

In boiling down the syrup obtained from the drainage of the first crop of crystals, less care is required, a small grain being preferred on account of carrying more syrup than a larger grain. In boiling the lowest grade of syrup it is customary to make what is technically called a "jelly;" in other words, the formation of grain is entirely avoided, and the result is left for several days in tanks, in order that crystals may form. There are generally three qualities of crushed sugar made, viz., whites, mediums, and yellows, the whites constituting nearly half of the entire produce; but the proportions of the different kinds vary to some extent with the kind of raw sugar employed. The total produce of 100 tons of raw sugar should not be less than 95 tons.

The separation of the crystals from the syrup with which they are mixed is effected in an apparatus called a centrifugal machine, which is simply a perforated basket revolving at great speed, so that the periphery travels at something like 100 miles an hour. The drainage of the crystals occupies from three to twenty minutes, according to quality; and in the case of the finest and whitest variety, a dash of cold water is sometimes given in order to wash off the adhering syrup.

And now I must bring my lecture to a close, and have to thank you for the kind attention you have given to the subject. I feel that I owe some apology to the scientific chemists present, who must have listened, I fear, with impatience to details in which they can have felt little interest. I have endeavoured to avoid mechanical details as far as possible, while trying at the same time to exhibit a connected view of the whole process; and to the sugar refiners who have favoured me with their presence I have to say, that it is impossible in a single lecture to give anything like a complete description of all the improvements that have during the last few years been introduced, much less to describe the results of the investigations connected with this branch of industry with which I have been engaged. The field of inquiry is one that is sure to be fruitful of valuable results to any careful observer, and I trust that my few remarks, if not otherwise useful, may at least have the effect of attracting attention to a subject of great importance.

ROUGH NOTES TAKEN ON A FLYING VISIT TO THE NORTHERN DISTRICT OF BRITISH HONDURAS.

The whole of the northern district is nearly a dead flat, save a few small hillocks or ridges, and some shallow basins with a very gentle incline from the frontier to the sea, giving a slight undulation to a plain of about one thousand square miles, covered with the valuable native forest trees and the rank vegetation peculiar to the Tropics, excepting the patches of cultivation, here and there, where the plantations and ranchos are established, and a few sugar heads begin to raise their heads.

There are several lagoons, and comparatively few swamps and marshes, with abundance of logwood and mahogany. The soil is a vegetable mould, a thin layer of decayed vegetable matter, *humus*, of some 12 to 18 inches, deposited on a thick sub-stratum of decomposed limestone, formed into a hard compact mass of white calcareous marl, which may be cut into blocks or burnt into a carbonate for building purposes; but as there is no gravel or sand, these would have to be procured elsewhere on the coast to form mortar.

This surface soil, being a rich black mould, is well adapted to the sugar cane and other tropical plants. It is thinly scattered over the stony marl, to the depth, in some localities, of only 3 inches, increasing in thickness as you penetrate inland, while, in some places, the ground is bare, and the hard white marl crops out and renders the spots barren and unfit for cultivation.

In the sinking of wells at Corosal, madrepores have been found at a depth of 30 feet, and recently, at Caledonia, a bed of fossil oysters was discovered 17 feet below the surface. The water is brackish, dark and fetid at first, but soon becomes fit for common purposes, but hardly ever to drink.

In the rainy season the ground becomes sticky and adhesive (viscous), very trying to man and beast; but in the dry it does not cake up, and crack, and burn like clay, but becomes friable and crumbles into a fine powder, which the very heavy dews at night keep moist and fresh. Hence it is, perhaps, that the canes might ratoon so long as they are said to do. But still I doubt if they could do so beyond a limited period without fallowing or manure, or returning to the soil what may have been abstracted by the produce. The practice of burning off the fields must destroy the roots of the canes and what there is of the soluble salts and volatile organic matters, substituting too much potash, and I fear a long drought would almost ruin the estates.

I have seen canes planted when the first plantations were opened up five or six years ago, still in a passably good condition, but small, with short joints, and far inferior to some in the West India Islands, their worn-out and exhausted soils notwithstanding. And I was shown a field said to be 20 years ratoons (!) without manure, the canes of which, though very poor, produced a fair quantum of sugar. As a rule, the plants are not so luxuriant, and the canes not so large and succulent as those of the southern district; but they appear to contain more saccharine matter in proportion. I have been assured that canes planted at the time of the Bucalar exodus, some 20 years ago, have been ratooning ever since, never supplied or manured, very sparingly cleaned by cutting down the brushwood between, with the macheat, the hoe being seldom used, except in planting, and the plough is unknown, perhaps not as yet required.

The uplands are so far in the interior that very little of their débris can reach these parts; hence the superficial soil is composed principally of the decayed droppings of the forest, whereas, in the southern district, where the hills are nearer the coast and the irrigation greater, from the numerous streams that cross the country, the surface soil is alluvial—a thick loam formed of the silt and disintegrated matter of those hills.

It appears to me that a line drawn from the mouth of the Belize River to Indian Church (where I am told the limestone crops out in blocks like marble) on the one side, and another along the Rio Hondo on the other (on the north bank of which, the Yucatan side, the highlands commence), would embrace a region, the formation of which consists of this thin surface soil, super-posited on the indurated marl; while on the south of the first line the base is a true limestone, with a thick covering of loamy clay, in some places 5 to 6 feet deep. But I am told that to the west of the pine ridges about Booth's River, the Bravo, Blue Creek, &c., the marl is over-topped by a thick stratum of blue clay under the surface soil.

I fix the first line on the River Belize because, from the many creeks that join it, and from the conformation of the country, the greater part of the washings is brought down on that side, and at the floodings the land is submerged and the detritus spread over a large surface, whereas comparatively little goes to the north, from the want of current in the New River, and the comparative paucity of irrigation there.

In the neighbourhood of the Sarstoon, and beyond, the sub-soil is a ferruginous sandstone, and the surface is mixed with quartz pebbles, mica, iron oxide, comminuted volcanic ejecta, and the remains of other primitive rocks, disintegrated from the mountains in the immediate vicinity; and I suspect that in the course of time, as the country becomes more explored and better developed, gold-bearing quartz and other precious metals and minerals will be found.

Corosal, the principal town in the northern district, and the oldest settled village in the colony, occupies an area of about half a square mile, and is situated on the coast, upon the dome of a cavernous formation, indicated by the hollow sound of horses' hoofs as they gallop along the streets; and on examining the ledges on the sea-shore, the old rotten crumbling coralline deposits are seen decayed and decaying, porous and honey-combed throughout. Indeed, it seems that a range of reefs originally extended all the way to Ambergris Island (for the banks of Consejo, Rowley's Bight, Rocky Point, and Bulk Head, &c., correspond exactly with those on the opposite side), and being hollow and worn in the manner peculiar to some of the tertiary limestone formations, must have caved in, crumbled and sunk, from some internal convulsion; and the sea rushing in, formed the Bay of Chetumal, and the débris, commingling with the waters, produced that thick sediment of white clayey marl on the bottom in which no fish can live, and to which the Hondo and the other rivers are continually adding, as they flow through channels of the same calcareous nature, imparting to the water a milk white colour.

There are about 500 houses in Corosal, built generally in the rude native style, with no flooring, with thatched roofs, and sides stockaded and plastered with clay and whitewash; but several of two stories have been lately erected of stone and wood, boarded and floored and arranged in regular order; there is a Methodist chapel and a fine large Roman Catholic church, the latter built of stone, with a roomy residence for the priest in the courtyard behind, and the streets are laid out at right angles, with a neat little square or plaza in the centre, so that the little township presents a cheerful, healthy, and civilized appearance.

There are several schools, well attended, in which the elements of education are taught, and the English and Spanish languages simultaneously cultivated with success.

About six years ago, when I first visited the place, the street fronting the sea was a fine wide alameda, but now the water has encroached very much, in some places as much as 10 feet, so that the street is considerably narrowed, and unless banked up, the sea will, in course of time, reach the threshold of the houses and undermine them altogether.

The population of Corosal proper is about 2,000, chiefly Indians and Spanish creoles, natives of Yucatan and Guatemala, with a few shopkeepers from Belize; but the whole estate, about 60 square miles, contains about three to four thousand souls. The fee simple is in Mr. John Carmichael, who rents out a considerable portion of the land, and receives an income of about 10,000 dollars per annum.

The place is dotted over with several little plantations called "ranchos" and "milpas," 10, 20, to 100 acres in extent, where, besides the sugar cane, plantains, corn, rice, and other provisions are grown, and sugar and rum manufactured in a primitive way, with small alembics, rudely constructed, and wooden mills worked by cattle; but the produce is of excellent quality, and the cultivation realizes a remunerative price at the Belize market. They carry on their operations at a comparatively low expenditure, as their labourers are chiefly their own countrymen (native Indians), who are content with but little pay and no rations.

Mr. Carmichael himself has two or three sugar estates, one with the appliances of steam; but he has sold out one or two to some of the American immigrants lately settled there.

He is now settled on San Andres estate, the first spot settled upon by the Spaniards at the exode from Bucalar about 20 years ago, and where sugar was first made in this colony, and where it is still made from canes said to have been planted at that time and ratooning ever since, without manure and without culture, save such as is peculiar to the rough system of the native; but, from the plan he has lately adopted, the estate has improved wonderfully. The canes look well, though I cannot compliment him on the tillage. The grass and brushwood are still permitted to grow up with the cane, and are not destroyed till after crop, when the fields are burnt off and the stumps and germs allowed to sprout again, and weeds, and bush, and cane grow up together till next crop, very little weeding being performed in the meantime.

The canes, like on all other estates, are planted too near (6 feet apart is the usual distance in the Islands), and not deep enough. The subsoil should be turned up by deep ploughing and holing, so that the roots of the cane might penetrate the marl, which, however forbidding in look, when crumbled and mixed with sufficient vegetable soil, affords abundant nourishment to the cane.

All planters know that the root of the cane has a tendency to grow out of the soil, and when the plant has but a thin covering, the rains soon wash that away and leave the plant exposed to the scorching rays of the sun. Add to this the annual burning off of the fields, and one can easily guess how long a piece would ratoon.

Besides, when planted closely together, the leaves soon intertwine and mingle, and the field becomes impenetrable, leaving no room for the passage of air, or the necessary weeding and banking during the progress of growth. A fair distance gives large stools and full succulent canes; too close furnishes numerous little reeds with no substance, choking one another, and struggling for the tittle of nourishment to be divided amongst so many sprouts.

There is also too great a waste of megass on all the estates. In a country like this, where wood is so abundant and near at hand, it should be used as fuel instead of megass, which, together with the cane tops, should be returned to the soil, green, so as to compensate for the substances withdrawn in the sugar. The great principle in agriculture is to return to the soil in one way or another, by manure, green bush, top dressing, alternate crops, fallowing, &c., as much as possible of the matter abstracted by the cultivation, and where this is neglected, the richest soil soon becomes exhausted and the estate goes to grief; still, San Andres has already made 50 casks (about 40 tons), and expects to make at least 100 more, on a cultivation of 100 acres; and as the proprietor is an energetic, persevering, old gentleman, I have no doubt that he will eventually effect a great change, and end in established success—a destiny I most sincerely wish he may soon accomplish.

Caledonia is one of the largest and best laid out estates in the quarter. Messrs. Kindred & Phillips have spared no expense in fitting it up. They have imported one of Fletcher's largest engines, capable of producing 10 tons a day, and the works are erected on a solid foundation and on regular scientific principles, with all the appliances and modern improvements, coming up to the best I have seen in any of the Islands, and similar, I understand, to the one now being erected by Messrs. Young, Toledo, and Co., at Seven Hills. It has three clarifiers and two taches, with the usual battery of three coppers (called here "kettles"), but the engine can well supply a double set. With less than 500 acres in canes, and 100 mules and 100 head of oxen, the estate, in my opinion, cannot be profitably worked. The proprietors, however, I understand, do not contemplate any further improvements (save extending the cultivation) till they are satisfied as to the success of the Concretor principle.

They have about 250 acres in canes at present, but only about half can be made available this crop, some of which are two year ratoons and stand overs, and do not yield very much just now ; but the next two or three months are the best yielding season, when doubtless the juice will improve. The rest are young plants, clean and healthy, and coming on luxuriantly. They have 30 tierces on the stanchions, and I calculate they ought to make 150 tons this year. The number of gallons of juice to the ton of sugar ranges from 1,500 to 3,000, and the density per Baumé is from 10° to 13°.

The planters all make a larger estimate of the produce of their fields, but I am not aware that any estate has ever realised an average of more than two tons the acre. In fact, the experiment has never been tried on an extensive scale, and for the simple reason that there has never been (and there is not yet) an estate proper, regularly established long enough to have fairly tried it on.

On some detached pieces or isolated patches, where the soil is deeper than usual, a larger proportion may doubtless have been obtained, but I question whether three and four tons per acre should be taken as a general estimate throughout. At the same time I must in candour and fairness say, that in the face of the Rancheros' system of cultivation, or rather want of system, the fact of their being able to work their own little plantations at a fair profit, notwithstanding their negligence of the cane from its first sprouting to its maturity, and the other fact of many of the larger fields ratooning for several years without scientific culture and continuing to produce an extraordinary yield, show the marvellous fertility of the soil; and that in spite of the lightness of the upper strata, there must be some properties in it peculiarly adapted to the growth and sustenance of the plant. This anomaly of the long duration and extraordinary yield of the cane here is so often reiterated by every planter, that one becomes at last almost reconciled to the apparent paradox.

They are still levelling down the forests, clearing out land, and opening up roads at Caledonia, but it requires a large capital to carry out these tentative operations, and some years must elapse before a good return on the outlay can begin to flow in; for in the first year only half of the cleared land can be planted, the other half being occupied by the dead stumps. In the second year they may have rotted or to be easier rooted out, so that it is only in the third year after felling that one can look for a fair return out of a given area planted; and even then another year must pass before the maximum yield can be expected, for plant canes seldom produce so much sugar as first and second ratoons well cared for, and it is only then that the cane arrives at full yielding condition. Where then is the estate here of which it can be said this result has been fully realized?

There is a growing village at the Barcadier at Caledonia, by the river-bank, which at present contains about 40 huts, where the labourers and some independent settlers are located, and a little retail shop supplies many necessaries from Belize, which is a great convenience to the people. Besides this, some 20 new huts have been erected nearer the works for future hands, and a tramway is about to be constructed from the works to the shipping place, so that, upon the whole, the future prospects of the property are very hopeful and encouraging.

The other estates in the quarter are on a smaller scale than Caledonia, with inferior engines and machinery. I did not visit them all, but I understand that they are all more or less on a par. On those I visited the canes are mostly old ratoons and stand overs, and the fields appear neglected if not exhausted, and some of them require new land to be opened up, excepting Tower Hill and Indian

Church, which I understand are in a very flourishing condition. Large improvements are being made on all of them, in the works and in the fields, by the American planters lately arrived, and I am told most excellent sugar, purified with sulphur, is made at Tower Hill by Mr. Price, the manager, from Louisiana; but this description of sugar does not keep, as it soon becomes infected with vermin.

Indian Church is the crack estate of the quarter, and more extensively cultivated than any. I regret that time did not permit me to reach that length, as it is said that the soil is deeper and richer than in other parts, the geological features more fully developed, and the scenery around more picturesque; the canes of enormous size, larger than those in the south and yielding abundantly. A large engine is being erected with powerful machinery, &c., on a new principle, with all the appliances and modern improvements, and a Concretor is about to be added and several scientific operations commenced. The British Honduras Company were the first, I believe, to take the initiative and attempt to lead the industry of the country to agricultural pursuits, and they have been at vast expense to promote the success of sugar making; and although they have had great difficulties to contend with, and have met with many disappointments, their enterprise has not slackened, and they are still persevering in their efforts and continuing in the race of progress, and, I hope, prosperity.

It appears to be the rule not to weed or trouble the canes once they are cut, for almost every field that I saw was unweeded and choked up with weeds, and yet they make sugar. Every planter knows that unless the canes are weeded two or three times while sprouting, till they overshadow the ground before the weeds spring up, it will be impossible to go through them with the hoe after they are grown up; but here they do not seem to know the pithy proverb of the windward and leeward islands, that—

"The sugar is made in the field,
"The boiling house shows but the yield,
"And there, as your canes are kept clean,
"So here's the effect fully seen."

But, indeed, there are very few really energetic practical men in in the colony acquainted with the routine of tropical plantership; and no regular system of cultivation is adopted, all, with very few exceptions indeed, are as yet mere theorists and experimentalists, groping in the dark, and it is only surprising that they have hitherto got on so well.

All the estates have huts ready built for the labourers, where they appear comfortable enough, but the women do not work in the fields or attend the mill and megass as in the islands; they remain at home to cook their husbands' meals and attend to other domestic avocations.

The sugar is of a rather dark colour, (except what is made expressly for local consumption) though of good grain; but I believe this is done to order, as it is found that the difference in the price of the finer sorts in the home markets is not equivalent to the difference in the duty.

Orange Walk is the next village of importance in the district. It is situated about 30 miles from Corosal, on a little rising ground on the right bank of the river going up, from which a fine view of the country round can be obtained. The lots are not, as at Corosal, rented out to parties, but are mostly the freeholds of the occupants.

They are all railed in, and have their outhouses and little kitchen and flower gardens, their poultry yard, "corals" and "patios," cosily and neatly arrainged within, which give the whole a very lively and animated appearance. While the troops were there a considerable amount of business was done, but the place suffered very much from the fire of the last two years, and is now but slowly recovering from the shock. There are about 200 houses, amongst them several gay little shops, with a good variety of articles from Belize, and the population numbers at present about 800 souls, consisting principally of logwood cutters, rancheros, and labourers on the neighbouring estates.

San Esteban is a neat little village on the left bank going up, midway between Caledonia and Orange Walk. Don Florencio Vega is the proprietor, who receives about 2000 dols. rental from the occupiers. It contains about 200 houses and 1000 souls, chiefly logwood cutters and builders of bungays and other small craft. A great quantity of corn, plantains, pigs, poultry, &c., used to be produced here and at Orange Walk for the supply of the district as well as Belize, but it is not in a very flourishing condition just now.

There are other villages and little settlements about with small clusters of population, such as Xaibe, Consejo, Sartaneja, Rocky Point, &c., but I had not time to visit them.

The roads about are wide and good, intersecting the country in various directions, and affording easy intercommunication and pleasant riding to the different estates and ranchos, but the New River is the principal highway for travellers up country. It runs from above the lagoon at Indian Church, down to the bight in Corosal bay, some 100 miles, navigable all the way for small craft, and the estates are conveniently situated in the vicinity of the banks for the shipment of their produce.

It is a dull sluggish stream, with no rapids and little or no current, and it seldom or never overflows its banks, as all the backwater flows through black creek into the Belize river. Hence the want of alluvium on *this* side, and the superabundance on *that*. Besides this, there are only the northern river and fresh water creek to irrigate the land, and these are comparatively small streams, but there seems to be no lack of moisture, and the water is not fresh but brackish, and hardly drinkable even up to Indian Church.

The navigation is tedious and monotonous, as it is a poling all the way in bungays, or paddling in canoes amongst bush and jungle and along a swampy margin till one gets up to the source. But, San Esteban is a sort of half-way house, and I was agreeably surprised when I landed there on the 10th of February, to find the people in the midst of this wilderness celebrating this carnival. The men neatly dressed, and the women, some very pretty Indian girls amongst them, in a peculiar national costume, decorated and adorned with many gold chains and brilliant jewels in a very tasty manner, gracefully dancing and enjoying themselves on the open lawn—thus presenting an agreeable contrast to the sameness of the scene we had just passed through.

There are several artificial mounds, cairns, or tumuli in different places, built up of the native marlstone, the uses of which remains a mystery to this day. They appear to have served as a sort of watch towers or beacons to the aboriginal inhabitants, but no one can now tell the exact purpose for which they were constructed.

At Caledonia in particular is a range of seven, disposed in a sort of crescent along the banks of the river, which seem to have subserved the purpose of a fortification at the entrance of a town or city. Many blocks of the stone that have been dug up shew evident marks of art and skilled workmanship, and some people think they must have been used as mausoleums for the dead, but one or two that have been excavated have not confirmed the supposition. Several little images were found, some of baked clay, shewing great ingenuity, and some carved out of the native stone, in excellent preservation, their delicate chiselings proving that the artists, whosoever they were, had attained to considerable perfection in sculpture.

At Corosal are many large ones scattered about, several of which I inspected on a former occasion. One was about 60 feet high, with a large circular base tapering at top like a truncated cone or pyramid; and another about 100 feet square, bearing north and south, divided into several compartments of different dimensions, evidently a sort of palace or temple, with reception hall, chambers, and anti-chambers, &c., all ruinate and crumbling into dust. The mystery of these buildings I apprehend will never be cleared up.

Many of the inhabitants who quitted at the time of the Indian panic are now gradually returning, and the people all appear lively, industrious and thrifty; and this being crop-time, and the estates in full operation, the labourers are fully occupied, cheerful and happy, and seem to have no more fear of Indian raids or any other bug-bear. They are, however, a little awkward at their new employments, and somewhat disorganised, or rather, I should say, not yet properly organised to plantation work, but this was to be expected in the infancy of a new regime, and I have no doubt that with good management and care, and proper temper and tact, they will eventually be induced to take to their new vocation *con amore*.

There is an Indian custom, a great festival, annually held here, called the "Xaibe Fiesta," which tends in no small degree to demoralize the labouring population. In the first week in the month of May, when the southern cross is on the meridian about midnight, the Indians, accompanied by the other labourers from all parts of the district, and patronised by the gentry, assemble at the village of Xaibe to celebrate the feast for a week, with dancing, drinking, and gambling, and all sorts of licentious dissipation. The square in the centre of the village, where, by the way, there is a Roman Catholic Chapel, is crowded with little booths and tables, on which liquors are exposed for sale, and gaming with cards and dice is carried on night and day. The first day is devoted to the Indians proper, when a number of women called "Mestizas," in gawdy, fantastic dresses, their hair decorated with long streamers of bright coloured ribbon, and their persons with a profusion of gold ornaments, bracelets, chains, amulets, &c., assemble in a large barn open at the sides, and built expressly for the purpose, and commence dancing to a dull monotonous air, with the men of their tribe called, "Vaqueros," who take them out singly, one after the other, and perform a sort of war dance, in a tame, lifeless, unimpassioned manner, apparently, however, very significant and full of meaning to themselves; the men making sundry genuflexions, gestures, and gyrations, by no means very intelligible, till they have gone through the whole circle of attending women. These, without grace or elegance in their movements, their dull stolid faces and vacant empty gaze, expressive neither of animation or enjoyment, hop about, listlessly, like so many automata; while a great concourse of the gentle and simple crowd around to look on.

It is the practice to select a stranger, and, *nolens volens*, powerless to decline the honour, elect him master of the feast. He is then taken to another part of the square, placed in a litter made of twigs and branches, and carried on the shoulders of four men, who, preceded by a band of music and followed by a crowd, march in triumphant procession all round the square, and then take him into the barn and place him in a chair at one end of the room. The fairest lady of the company, previously decided upon, is then chosen and placed beside him as his consort. He is then said to represent a great lord of the manor or casique presiding over the amusements of his subjects. There he sits for hours, with no very comfortable feelings, undergoing a sort of penance, looking at the dancers, and inwardly reflecting on the degradation to which the selfish policy of man may reduce his species. After the dance is over he calls up the women one by one, compliments them on their performance and their good behaviour during the past year, and pays them off their wages in hard cash. Heretofore, this used to be in dollars, but latterly, from one shilling to half a crown is the range, according to the liberality of his lordship's temperament, and which in the end amounts to a good round sum; so that, eventually, the temporary casique finds he has been most woefully sold, and has had to pay dearly for his involuntary honours.

After this, he and his consort retire to enjoy a sumptuous dejeuner, prepared in another building, leaving the Indians to indulge, to their heart's content, in a liberal supply of corn cakes, tortillas, and catamalas, and revel in exciting libations to their traditional gods and heroes.

In the evening the gentry and visitors take their turn, and commence dancing to music of a more civilized and intelligent sort, performed by the same professors, who, to do them justice, acquit themselves very creditably on violins, pipes, and brass instruments.

The next night the same orgies are repeated, (except that part appropriate to the Indians) all the company mixing together promiscuously, and having a jolly bout of it till the peep of day. This is continued day and night during the whole week, accompanied with gambling, discharging of guns, display of fireworks, &c., the employers taking it by turns to defray the expense, and contributing, by their presence and participation, to encourage and perpetuate this ruinous custom, a relict of the superstitious rites and ceremonies of a barbarous age. To the credit of the people be it said that rows and shindies seldom occur. The Indian drinks his fill and quietly lays him down to sleep out his debauch.

The consequence of all this is, that for the next fortnight no work is done. The labourers take the first week to rest themselves and recover from the effects of their dissipation, and in the second week they resort to their milpas, to prepare their grounds for the planting season, now fast approaching; while the master, anxious to take in the rest of his produce before the rains set in, is left to finish his operations as best he may, and sometimes the wet overtakes him with a great part of his canes still in the ground, which he is thus compelled to leave as stand overs for another year, to his great detriment and loss; and thus hundreds of pounds are yearly sacrificed to the shade of a savage custom which injures the interests of the employer, corrupts the morals of the people, and promotes a degree of vice and depravity, that has become a public scandal, to tolerate which is a disgrace and a reproach to a civilized community.

The planters are all aware of the evil tendency of this odious sarturnalia, and say, in self defence, that they are obliged to connive at it in order to keep their people in good humour, and induce them to remain in their service; but, however much this necessity might have been felt in the infancy of the colony, when the staple of the country was mahogany and logwood, which required no continuous labour save at one season of the year; now that attention is to be turned to agriculture, and especially to the cultivation of the cane and the manufacture of sugar, which, more than any other species of industry, require constant application and uninterrupted labour; to submit to such a sacrifice at the shrine of Bacchus, and countenance and encourage a usage whose advent occurs at a critical time, in the midst of crop, when the utmost energy and exertion are required to reap the reward of all the planter's previous toil—is a suicidal policy that must subvert his best interests, and entail ruin in the end.

Why not unite to abolish it altogether, or substitute another season, either during the Christmas holidays or after crop, as a sort of harvest home, to celebrate these revelries; gradually divesting them of their heathenish accompaniments, till time shall eventually wipe off the recollection of those ancient traditions, and connect the festivities with more modern and enlightened associations, and thus, imperceptibly, wean over the Indian to the change?

The bull fights that used to be the *sine qua non* of these revels have been suddenly abolished, and I see no reason why the Bacchanalian accessories may not also be finally exterminated.

(To be continued.)

SUGAR, GLUCOSE, AND SACCHARIMETRY.

By M. DUBRUNFAUT.

(*Continued from page* 213.)

THUS, if we take a given weight of inverted sugar and transform it by means of the sodic or potassic reaction, as is done in our method of alkaline saccharimetry, this product will no longer act upon the copper; but if this transformation has been accomplished by means of lime, as often happens in the refinery and sugar factory, the glucose will still be able to reduce the oxide of copper to a certain extent; nevertheless, there will be this difference, that the glucose which before the action by lime would have indicated two per cent., will now indicate only one. We may then conclude from this that the action of inverted sugar has different exponents before and after the treatment by lime, and that these two exponents bear the proportion of two to one.*

Thus, we may understand that in applying the test to products which contain glucose transformed into calcic salts by the lime, these salts may yet act in the same manner as glucose itself. We have seen molasses which, affected by this cause have indicated on analysis 10 per cent. of glucose, when in fact it contained only 2 per cent.; and as the molasses was intended for the distillery where glucose is accounted as sugar, the error committed was entirely to the prejudice of the buyer.

In sugar a similar error would be to the prejudice of the seller

* The state of our investigations into this kind of reactions is not sufficiently advanced to enable us to draw up definitely a precise statement of facts. We confine ourselves to pointing out some of these in a summary manner, intending to revert again to the question before long.

if the correction of the glucose co-efficient was applied to it. Our alkaline method applied in these conditions does not correct the error which we have noted; in fact, the derivatives of glucose produced by lime give the same indications as glucose in the alkaline test.

It is to avoid these causes of error that we have indicated the following modification of our alkaline saccharimetrical method.

Instead of destroying the glucose by standardised alkaline liquid, sodic or potassic, we destroy it by a standardised solution of sucrate of lime of sufficient strength exactly to neutralize the sulphuric liquid of Gay-Lussac.

The amount of lime which disappears by heating glucose to the boiling point corresponds very nearly to 1½ equivalents, as with the sodic liquid, and thus the proportion of glucose may be estimated with some degree of certainty and with approximate correctness.

At the same time it must be remembered that this process is not so sensitive as the copper test, and that it cannot be applied to minute proportions of glucose; but it compensates for this imperfection by removing the chances of error which we have noted. It is, in fact, by this means that we have been able to prove that a molasses which under the copper test indicated 10 per cent. of glucose, in reality only contained 2 per cent.

At all events this method, well managed will be a useful means of verifying other processes. Thus, with the copper test applied in the search for glucose, if the presence of calcic derivatives showing as glucose is suspected, it may be recognised by the sucrate of lime process, which will separate the two products; by using the sodic method, we should transform the glucose and its calcic derivatives into products which are in no degree affected by the copper or lime tests.

Here, then, we have a collection of processes valuable as capable of determining the presence of glucose in the products of our sugar factories. They may in addition furnish other useful indications, and make known for example whether the glucose is produced during the process of manufacture.

Generally the salts of lime which are found in the residual molasses are produced from transformed glucose, which has given birth to the derived acids; and as these acids are indicated by the copper and sodic tests, it is always possible by the use of these means, in the way we have pointed out, to determine (as far as regards the glucose impurity) the true value of the processes which have been employed in the manufacture.

It is by the use of methods of this kind applied to molasses that we have been able, by a knowledge of the cause, to form a judgment on the errors of the new methods of manufacture, on the faults of the sugars sold to the refiners, and, in short, on the evils which these products introduce into the operation of the refineries.

We do not yet know the exact value of the co-efficient which should be equitably applied to the glucose previously existing in the sugars of commerce. It has been proposed to deduct from the saccharimetiical value, once or twice the weight of the glucose found, and although these corrections may be the most frequently too small, yet it will protect the sellers, who believe themselves already great losers by the application of the co-efficient five applied to the salts.

Upon this delicate point, it is our duty to pronounce our unreserved opinion, whatever may be the consequences; we owe it to the truth, to true progress, and to the prosperity of an industry which is of importance to us in more ways than one.

The defective methods of manufacture which have been adopted by the producer of sugar are the primary cause of the evils which we have noted in the refined sugars of commerce. These evils might exist at a former period, but then they were the consequences of the normal glucose impurity of colonial sugars.

During the whole time that the sugar industry carefully practised the alkaline system, refined beet sugars were free from glucose as well as the raw; and when it was found in the products of refineries worked on this principle, it had its source in the admixture of colonial sugars and in the erroneous methods used in refining.

In fact, we may recollect that at another period the slowness of the process, and the system followed in refineries were peculiarly favourable to the transformation of crystallizable sugar into glucose by fermentation.

We have proved by experiment that beet sugars actually sold and delivered are often acid, and if they are slightly alkaline on leaving the factories, they lose this character after being warehoused a short time.

We have proved by analysis of some boxes of the official standard sugar that this alteration is produced in time, even in the small samples; and that this modification appears to be the more active and the more rapid when the recently made sugar is of whiter colour.

What can be more paradoxical than these facts? It is generally, and always has been believed, that the whiteness of the sugar is an indication of its purity: that the whitest sugars are the purest, and keep the best.

Is this principle false? We do not admit it; but the case we are considering is exceptional, and it is easy to understand and explain it.

The calcic boiling in the free air, which produced good akaline sugars in the old process—that is to say, sugars strongly crystallized and freed from molasses, but of a yellow or red shade, was the true cause of these qualities; and in preserving to the manufactured sugar the original alkaline character, it had radically destroyed the nitrogenous matter which tended to produce fermentation. The sugars thus purified might be kept in the warehouse without alteration; they refined well, but their coloration was carried into the produce; and notwithstanding the use of more animal charcoal to decolorize them, they produced sugar of a yellow cast, which to the eyes of ignorant consumers, and these are by far the larger number, if not the generality, were depreciated.

The washing with syrup, which in the refinery completes the bleaching and purification of the loaves, required also a much greater consumption of white sugar and more time for working.

To avoid these inconveniences some purely speculative workers have carried out this fact or illusion, that in suppressing the boiling with lime the syrups colour less, and that in subnitting them to new apparatus they prevent calcareous incrustations. Thus notwithstanding their really evident vices, these syrups can be submitted without difficulty to a crystalline purification, known by the name of "cuite en grains."

Armed with these methods, the pretended inventors have based their speculations upon them: they have conceived the double carbonatation, the turbid defecation, and all those irregular modifications of known agents and processes which alter the products and substitute for the real some fictitious qualities, which finally conduce to the results which we have noted.*

The refiners who at a former period were the promoters and regulators of the progress of the sugar industry by giving for a long time the preference to the products of the alkaline method, have become in an interest perhaps little understood, the promoters and accomplices of a vicious method of manufacture.

The white grainy sugars, despite their radical vices, have the great advantage of being easily worked, which alone captivates the affections of the refiners. Their apparent purity, judged of by their colour, † allows of their being used without the

* These pretended progressive inventions had rise in Germany, where they are carried out with the same assurance, the same ignorance, the same effrontery, as in France. There, in fact, analyses made by the doctors have been shown, which establish by figures that the "turbid defecation" removes half of the impurities of the juice, and thus doubles the value of it. We have affirmed from the results of the most exact experiments that this process only eliminates the colouring principle; and that as regards the salts and the nitrogenous matters, the juice is inferior to the produce of the common alkaline method. On which side does the truth lie? Only ulterior discussion will show.

† It is believed that the manufacturers of white grainy sugar employ against the refiners the same subterfuge which the latter use against their customers—that is to say, they give them a blue tint which produces a fictitious white appearance, without which their impurity would be shown by the yellow cast. It is, in fact, known that refiners put into their loaf coppers some ultramarine, of which the blue colour, combined with the yellow colour of the impure sugar, produces a whiteness in accordance with the law of complimentary colours. This is, saving the difference of the

centrifugal or any other process whatever, either for washing loaves or as raw material for refining, and when added to the charge in the vacuum pan, they raise the colour of the concentrated syrups, and reduce the volume of the low products, which are, as we know, the most radical obstacle to the working of a large quantity.

Such are the real motives which have induced the refiners to accord a higher value to the impure white grainy sugars of commerce, and which have exclusively encouraged this kind of manufacture, and attributed to it a superiority, which is very questionable.

In fact, all the sugars produced by these new methods of manufacture are more or less defective, and the high price which refiners give for them is very often the result of an illusion or of erroneous calculation.

Already there is a little reaction from this infatuation, and the difference in price between the white and yellow sugars, which has been sometimes as much as 15 to 18 francs per 100 kilos. has now fallen to 9 or 10, at which it now regularly stands; but if the subject is thoroughly ventilated, the white grainy sugars will lose the favour they at present enjoy, and may even be driven from the market with as much ardour as they have found favour without sufficient reason.

Already less importance is now attached to the colour which has served as the basis of an absurd official classification. Sacchari-metrical and saline analyses have commenced the work of the regeneration of the trade in sugar, and when new light is thrown upon the question, complete justice will be done by restoring the industry to the path, which it never ought to have abandoned;

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colouring principle, the usual method of our laundresses, who correct the yellow tone of the badly washed linen with cobalt-blue. The principle is exactly the same in both cases; and, in fact, it is an unheard of thing that sensible men should be carried away by routine to practise such methods to give a purely fictitious character to a commercial product of the first importance—an article of food! Should not the consumer oppose this underhand dealing by refusing all sugars which, dissolved in water, eave a blue precipitate.

by a return to the alkaline working of sugars, which will keep well—*i. e.*, to sugars free from glucose and from glucose ferments.

Doubtless the refiners are able to bring about this renovation of the sugar industry by proceeding as they formerly did at another period; that is to say, at an epoch when the industry, misusing the vacuum apparatus, delivered faulty sugars, of which the defects were immediately shown in the process of refining.

The existing defects are of the same order, although balanced by certain illusory advantages which favour more or less the desires of the refiner, as we have noted, and facilitate the working of a large quantity; but the quality of the produce is certainly deteriorated, as is proved by the invariable presence of glucose in the refined sugar of commerce.

The discovery of glucose and its quantity is, then, of great importance from our point of view, inasmuch as it will enable the refiner to enter on the path of perfection which we have pointed out.

To attain this end mark the course that must be taken—
All raw sugar white or other, which is not freely alkaline, should be suspected, and if experiment shows that it contains glucose, it should be subjected to precise examination to determine its value. Thus, if the sugar has an acid reaction, and if its glucose analysis shows the presence of true glucose, and not of its derivatives, it should lose the place which its colour and granular crystals have given it, and submit to a rebate.

Such a sugar, in fact, used in the refinery always introduces not only glucose ready formed, but also ferments which produce this impurity; it thus becomes a means of the modification of crystallizable sugar, which it is sought in vain to combat by calcic alkalinity. In this case, in truth, when the analysis only shows in the sugar in question some thousandths of glucose, it is not on an equivalent quantity that rebate should properly be made, but on hundredths, because such a sugar made in the refinery alters some hundredths of good sugar, and therefore a rebate expressed in hundredths would be perfectly legitimate and justifiable.

Besides, the fault of this sort of sugar can be discovered by other indications. Thus, sugar stored in large samples, as in bags, if not completely dry, undergoes fermentation, and loses its free granular state, and clots together, like farina in the heat of summer. The sugar also contracts a characteristic odour.

In submitting this sugar to what we have termed the calcic proof, it gives off ammonia, easily recognised by the smell. In fact, every circumstance connected with sugar of this sort shows the evils of defective manufacture; that is to say, of an incomplete defecation, which, while promoting the blanching of it, leaves impurities in the syrup which an alkali would eliminate or transform.

We submit that even an exaggerated rebate, based on the presence of glucose, or its derivatives, in the sugars of commerce, is perfectly just, when these impurities are the result of a vicious system of manufacture, and it is evident that this rebate, considered as a fine, would have for its aim and effect the turning of the sugar manufacture away from a false system, which has been adopted under the pretence of progress.

Let us see what would be the effect of this on the sugars of commerce, and consequently on the sugar industry.

If the alkaline process again takes the lead in our sugar factories, the raw sugars will recover their rank according to quality, and it is evident that this return to true principle will not prevent in any degree legitimate improvement which may be sought for from the carbonic decoloration, animal charcoal, or the centrifugal, from perfected apparatus and from all the processes of purification which have for their aim the delivery to the refiner of the purest and whitest sugar possible.

In these conditions sugars containing no glucose, and freely alkaline, may be warehoused without the fear of any alteration or fermentation; they would not afford to the refiner any pretext for a recognized allowance, whilst they would be free from the evils which at present affect the working and the produce of refineries.

In such conditions, and with such raw material, the refiners would be able, as advantageously as the makers, to adopt the alkaline method, and enjoy the benefits of this process, which is eminently preservative of the sugar, and which cannot be carried out while the present system prevails.

In fact, the glucose alteration being caused by the impurity of the raw material, begins to appear in the first process of the refinery—*i.e.*, in the melting, and is invariably developed during all the subsequent processes; if, to combat this evil, the refiners have recourse to the calcic alkalinity, then from the clarification downwards, they transform the normal glucose into its derivatives, producing in it the known coloured derivative, and this mode of working by colouring the boiling syrup, annuls the benefit expected from the introduction of white grainy or centrifugal sugars into the pan.

The refiners, then, are obliged, in view of their mode of working, to take account in their offers, both of the pre-existing glucose and of the glucose ferments. This is the least of the evils in the present state of the question, and when they use the lime to neutralize, it is only in working low produce, and with the single aim of combating the frothy fermentation.

By only one means can the refining industry overcome this difficulty, and that is the return to the alkaline method in the sugar factory, when the raw material being delivered free from glucose, a similar mode of working may be pursued in the refinery.

Then and then only refined sugars can be delivered to the consumer free from glucose, and then perhaps, also, it may be demanded of the refiners that they cease to apply to the sugar which we eat, the factitious process of bleaching, which the laundress applies to our linen.

The latest news from the colonial sugar countries is generally favourable both as regards the present and the coming crops. In Mauritius rain is required for the growing canes, but the hot dry weather has been favourable for the cutting of the present season's crop, which is still estimated to yield 125 to 130 thousand tons, of which it is expected that 50 thousand tons will be shipped for Europe, an equal quantity for Australia, and the remainder to India.—*Licht's Monthly Circular.*

ON SULPHITE OF PHOSPHATE OF LIME, THE NEW DISINFECTANT AND MANURE.

By Dr. B. Wilhelm Gerland.

Although the number of disinfectants is limited, the choice of a suitable one is difficult, as they all have some property which makes their use inconvenient. The most effective is Chlorine, but, being poisonous and destructive, it must be rejected in important cases. Carbolic acid is well known as an antiseptic; however, it deodorizes only by substituting its own strong smell. The metallic Salts and the Permanganates are in many instances very valuable; their disinfecting action is, however, limited to those substances with which they are brought into contact; but as they stain or destroy tissues, or other organic matter, and are expensive and poisonous, their use is restricted. Of greater importance is Sulphurous acid. Even small quantities have a surprising effect, and it is therefore used by several trades. Its application is easy, when it can be made by burning Sulphur at the place where it is wanted; but it is a highly irritating gas, even when mixed in minute proportion with the air, and rapidly tarnishes metallic surfaces, so that we can neither use it in our dwellings or stables. The aqueous solution of Sulphurous acid has not many advantages over the gas; its preparation is troublesome, its smell very strong, although containing but a few per cent., and it is rapidly affected by the air. The Sulphites are still more susceptible to this; moreover, their disinfecting power is considerably less than that of the acid; in fact, I have repeatedly observed, that when mixed with putrid matter they accelerated the decomposition, which was soon accompanied by an abundant generation of sulphuretted hydrogen. With these considerations I undertook an investigation of Sulphurous acid, in the hope of finding a suitable combination, and discovered a series of compounds of this acid with tribasic Phosphate of Lime, which are possessed of properties that are certain to make them interesting and important.

SOLUTION OF PHOSPHATE OF LIME IN SULPHUROUS ACID.—An aqueous solution of Sulphurous acid dissolves tribasic Phosphate of Lime, in whatever state it may be. If the gas is passed through water holding an excess of precipitated Phosphate of Lime in suspension, a solution of 1·3 sp. gr. is obtained. According to the analysis, it contains for one equivalent tribasic Phosphate of Lime, six equivalents Sulphurous acid, as the comparison between the numbers found and those calculated from that formula will show :—

ANALYSIS OF THE SOLUTION OF 1·300 SP. GR. 1,000 c. c. contain :—			The formula, $3\ CaO, PO_5, 6\ SO_2$, requires :—		
Sulphurous acid ..	218·38	Grms.	$6\ SO_2$ ..	192 ..	224·45
Sulphuric acid ..	0·70	,, ...	..	..	
Phosphoric acid ..	82·89	,, ...	PO_5 ..	71·4 ..	82·89
Lime	101·79	,, ...	$3\ CaO$ ..	84 ..	98·20
	403·76	,, ...		347·4 ..	405·54

Sulphurous acid also dissolves bone ash, but it acts slower than in the former experiment, nor have I yet succeeded in preparing a solution of such great density. The strongest solution obtained from bone ash had a specific gravity of 1·1708, and this liquor contained, in 1,000 c. c. :—

Sulphurous acid......	141·82	grms.
Sulphuric acid		
Phosphoric acid	47·42	,,
Magnesia	2·79	,,
Lime	59·69	,,
	251·72	

The formula $3\ Ca\ O, P\ O_5, 6\ S\ O_2$, requires for 47·42 Phosphoric acid :—

Sulphurous acid	127·50	
Phosphoric acid	47·42	
Lime	55·78	
		230·70
Excess of Lime of the analysis		3·91
,, Magnesia ,,		2·79
These two require Sulphurous acid		8·73
Excess of Sulphurous acid found		5·58
		251·71

The liquor contains Lime and Phosphoric acid in nearly the same proportion as the bone ash, but considerably more Magnesia; in fact, the Sulphurous acid has dissolved all the Magnesia of the bone ash, which was left in excess in the solution.

The proportion of Sulphurous acid in these liquors varies according to their strength. Those, for instance, of 1·060 sp. gr., contain 5 equivalents Sulphurous acid for 1 equivalent Phosphate of Lime, and in still weaker solutions we find this proportion reduced to 4 to 1.

These liquors have the smell and taste of Sulphurous acid, but to a considerably less extent than aqueous solutions of the gas with the same amount; nor do they lose it so readily, and contain a much greater quantity. As the Sulphurous acid has not lost its disinfecting power in these solutions, they are likely to prove of great value. They give remarkable reactions, but most of them being of purely scientific interest, we will omit them here, particularly as they are described in other places. The following, however, is of greater importance, and of more general interest:—

When the solution of Phosphate of Lime in Sulphurous acid is boiled, a precipitate is formed, and the latter escapes as gas. This decomposition requires long-continued boiling, considerably more than an aqueous solution of Sulphurous acid would need, to deprive it of the gas. The precipitate is white, crystalline, and dissolves under the microscope into hexagonal crystals, showing the faces of the column and the pyramid.

The analysis of the precipitate dried over sulphuric acid gave the following numbers:—

Sulphurous acid	15·61
Sulphuric acid	0·23
Phosphoric acid	34·48
Lime	39·89
Water	9·09
	99·30

These agree with the formula, 3 Ca O, P O_5, S O_2, 2 H O, which requires—

Sulphurous acid	15·58
Phosphoric acid	34·76
Lime	40·89
Water	8·77
	100·00

The substance is, consequently, *Sulphite of Phosphate of Lime.* It distinguishes itself from all other Sulphites by its stability, and is a white powder free from smell and taste, does not change in any way in either wet or dry air, or in the steam bath. After having been heated for three hours in an air bath to 130° C., it had lost 0·64 per cent. of water, whilst the amount of Sulphurous acid remained the same as before. The water is held strongly, and cannot be expelled except by a higher temperature, when at the same time a deeper going decomposition takes place, in consequence of which fumes of Sulphuric acid, metallic Sulphur, and Sulphurous acid, are given off with water; but the residue contains Sulphur, as Sulphate and Sulphide, even after having been heated to redness.

This Sulphite is insoluble in cold water. Long-continued boiling under exclusion of air causes a slight decomposition, and the water contains Phosphoric acid in very small proportion (according to my estimation, 0·02 per cent.)

Strong mineral acids decompose the compounds under effervescence of Sulphurous acid. Oxalic acid acts but very slowly on it, even when boiled. Acetic acid has scarcely any effect upon it; assisted by heat and the oxidizing effect of air, it dissolves it gradually.

Chlorine gas is readily absorbed by the dry powder, Sulphurous acid is oxidized, but no Sulphuric acid is formed, and only small quantities of Phosphate are rendered soluble. Dilute Iodine solution is instantaneously discoloured by the new compound, and the process is terminated when it is completely dissolved; a further addition of Iodine produces a permanent color. This affords an accurate and convenient mode of testing the amount of Sulphurous acid. The decomposition takes place according to the formula,

$$3\,CaO, PO_5, SO_2, 2\,HO + I = CaO, 2\,HO, PO_5 + CaO, SO_3 + CaI.$$

The Sulphite of Phosphate of Lime, although it perfectly resists the atmosphere, is speedily oxidized when buried in the earth. The following experiment explains the process undergone:—A layer of the compound, 1½ in. thick, was placed in a heavy clay soil (this was ascertained to be free from Lime and Phosphoric acid soluble in dilute Hydrochloric acid), covered with the same, and well beaten down. This sample was exhumed after two months (in October), and a portion with as little soil as possible submitted to analysis; 100 parts were found to contain:—

Sulphuric acid	18·59
Phosphoric acid	24·58
Lime	33·66

Sulphurous acid was not present. The Sulphite was oxidized, and this will have taken place according to the formula,

$$3\,CaO, PO_5, SO_2, 2\,HO + O = 2\,CaO, HO, PO_5 + CaO, SO_3 + HO.$$

The original substance contained, according to analysis (see p. 41), 34·5 per cent. Phosphoric acid, and 15·8 per cent. Sulphurous acid, which by oxidation yields 19·75 per cent. Sulphuric acid. The exhumed substance ought, according to this proportion, to contain for the quantity of Phosphoric acid found, namely, 24·58, 14 per cent. of Sulphuric acid; but the analysis shows 18·59 per cent.: that is an excess of 4½ per cent. sulphuric acid. It is therefore evident that the Phosphate has been dissolved at a quicker rate than the Sulphate of Lime. Calculating from the quantities of acids of the last analysis, the quantity of Lime which they require, we find,

	Per cent. Lime.
For 18·59 Sulphuric acid as $Ca\,O, S\,O_3$	13·01
And for 24·58 Phosphoric acid as $2\,Ca\,O, P\,O_5$	19·28
Total	32·29

But the exhumed sample really contained 33·66 per cent. Lime, or 1·37 per cent. more. Such an excess is to be expected when we consider the tendency of dibasic Phosphate of Lime to undergo a decomposition under the influence of water, by which a compound containing more Lime is left undissolved.

The Sulphite of Phosphate of Lime will therefore act when mixed with the soil, like a soluble Phosphate, and has the advantage over the latter of containing a higher percentage of Phosphoric acid, and of becoming soluble by degrees, so that floods and heavy rains are not likely to wash it off the land.

The new compound has the property of absorbing Ammonia when it is mixed with air, and this is probably of great importance for its functions as a disinfectant, as will be explained presently. It appears, however, that as ammonia is absorbed, the equivalent of Sulphurous acid becomes oxidized, and forms Sulphuric acid. A sample was placed under a loose shade beside a dish with water, and pieces of Carbonate of Ammonia, for four weeks, and subsequently for two days over Sulphuric acid. It was then found to contain:—

	Per cent.
Lime	39·08
Sulphurous acid	2·50
Ammonia..............................	5·60

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The Sulphite of Phosphate of Lime possesses antiseptic and disinfecting powers to a remarkable extent. When applied to putrid matter it will, in all probability, begin its action by absorbing the free Ammonia, and this is of importance, as the Ammonia, a product of putridity, greatly accelerates the same, and, being a highly volatile substance, will carry off other products of decay, which by themselves would not volatilize, or only sparingly. The new Sulphite goes further in its action: it arrests decay, and the worst smell will soon be greatly diminished and changed, or altogether removed. The most offensive putrid matter will by this means be rendered innocuous. The process by which this disinfection is accomplished is not yet sufficiently ascertained, but I have convinced myself that the larger the mass of matter, and the more advanced in putridity, and the warmer the temperature, the quicker and the more perfect is the action of the Sulphite. The Sulphurous acid becomes oxidized, and it is not unlikely that Ozone is formed at the same time. Nitric acid is found in every instance. It is astonishing how well sometimes this powder acts in disinfecting putrid matter when at a distance from it. For hot climates this disinfectant will prove of great benefit, and after having served its purpose, the resulting mixture of the same with organic matter will be a valuable manure.

My new Sulphite is of great value for stables and shippons When regularly strewn over the floor, a small quantity will be sufficient to remove the ammoniacal smell so peculiar to these localities. The beneficial effect of pure air upon health is generally acknowledged; how, then, can we expect domestic animals to thrive in stables where the air is often contaminated with Ammonia to such an extent that the rudest tests will show its presence? The regular application of this disinfectant is consequently of a threefold advantage to the farmer: it keeps the air in the stable pure, it enriches the dung with Phosphoric acid in a soluble state, and with Ammonia, which otherwise would be lost. The Sulphite will save more Ammonia than it is able to absorb, as, by preventing the decomposition of the dung, it prevents the formation of Ammonia, and leaves the organic substances containing Nitrogen intact, until the dung is brought on the land. Since the Peruvian guano fields are approaching exhaustion, the value of Ammonia is increasing, and it is a matter of importance to utilize that which we have at our doors, instead of allowing it to waste, and vitiate the atmosphere. It would be advisable to keep the dung under roof, so that the rain cannot wash off the most valuable constituents.

The Sulphite of Phosphate of Lime combines with its disinfecting power properties which recommend it for general use. It is a nice white powder, inodorous and tasteless, staining nothing, it easily dusts off garments, carpets, &c. It does not affect the most delicate colour or tarnish metals, and is perfectly harmless to animal life. Finally, it is a definite chemical compound, and therefore of regular composition.

These properties are also likely to recommend it for trial in Therapeutics.

All attempts to prepare a compound of Phosphate of Lime with two equivalents of Sulphurous acid have failed. The investigation of this subject is still occupying me, bnt as the described compounds of Sulphurous Acid and Phosphate of Lime are of great scientific interest, and are likely to become of importance for agricultural and sanitary purposes, particularly since they are now articles of commerce, I give the results so far obtained to the readers of "*The Sugar Cane.*"

Macclesfield, December, 1869.

THE CONCRETOR IN AUSTRALIA.

We have been favoured with the perusal of a letter from Dr. Nield of New South Wales, giving an account of the trial of (we believe) the first Concretor erected in any part of Australia. Whilst the letter shows that there are great difficulties to be overcome in the introduction of new apparatus into a comparatively new country, the results so far are of a decidedly encouraging character. By permission we reproduce the letter in our pages, being sure it will interest many of our readers.

New South Wales,
Port Macquarie,
October 4, 1869.

Dear Sirs,

I need not trouble you with a very long letter this month, but must be content to report progress. We, or rather I, have finished erecting the Concretor, the brickwork of the furnace being our *bête noire;* and have had three small trials, conducted according to the printed instructions and Mr. Fryer's most admirable hints. *None of us* who worked the Concretor had ever made a grain of sugar before, and I must own to a sense of temerity in venturing to use so beautiful and admirable, so complex, yet so simple, an apparatus. But we were careful, and had no accident. The brickwork was not dry, our fuel not good, the trays, especially the wrought-iron ones, were loaded with rust and dirt, which we could not get off at first. Everything was dirty, cylinder full of dust, our hot air did not reach 230°, other end not 100°, the defecation in the clarifiers was most imperfect, and there was more or less of salt water in the pipes (we are compelled to use salt water for our boiler). We did not expect any result but a mess; yet, despite all this, in two hours after being discharged, the concentrated material—I cannot call it syrup, it was so poorly cooked—began to granulate, and next morning (we had to finish it by lantern light) there was a good body of sugar. This was centrifugaled and liquored two days afterwards, and yielded a very light grey sugar—grey from being tinged by the rust, yet of a nice sweet taste. I should have previously stated that the cane crushed had lain long on the ground, blown down, but not broken off, and that the juice marked only 8½ to 9° Baumé. The mill expresses 60 and 62½ per cent. of juice. We felt—and our better experienced visitors expressed—that our result was a great success. Two days after our first crushing we tried a second; but our colonial steam boiler could only give us 10 to 17 or 18 lbs. of steam. Hence the boiling quite overran the crushing, and we had to stop—not, however, till we had turned out many gallons of rich syrup, which began to crystallize almost immediately. Our boiling had been much better, but fitful, owing to a furious Nor'-wester, and our heat had risen to 280° and 130°. We ended our day at the centrifugal as just named. On our third boiling things went better than ever. The juice was in a rich amber foam from end to end of trays, yet no burning; the heat was 330° to 150°, the discharge was going on continuously, and good-sized crystals formed in the shoot in the cylinder. We, however, ran the sugar and syrup into coolers to crystallize fully. We must centrifugal it when our boiler funnel has been put up again; we have taken it down to add 12 feet to it. I am quite satisfied with the Concretor and your beautiful machinery; both will do all promised for them, provided I have a proper supply of steam, and this I am hastening to get. I consider we are quite successful, but shall use coolers for the present, till our sugar runs so freely in the side shoot as to tempt us to put it at once in the centrifugal.

One of my visitors is the manager for the Sydney Sugar Company of their large Concretor (about being erected) on the Macleay. He was well satisfied—more so, by far, than myself—and declared that what he had seen us novices accomplish had taken a load of anxiety from his mind. I can assure you it has marvellously lightened my anxiety also. I believed in the Concretor, yet, when I found myself nearly alone in standing up for it, and was pitied for my blindness, sneered at for my folly, censured for my rashness, and laughed at by ignorance—when professed experts predicted my utter ruin, and even kindly acquaintances could give me no more encouragement than a cool "hope you will succeed," or a silent disbelief expressed by the eyes—I must confess to having had many an anxious hour, and no little burden to bear. But, as "nothing succeeds like success," smiles and congratulations are being exchanged for sneers and pity and "hopes," and my energies are being restrung to complete my works, and get through my work of this season.

Sincerely yours,

JOHN C. NIELD.

MEMORIAL ON THE SUGAR DUTIES.

It appears that a memorial has been drawn up in Antigua, for presentation to the Home Authorities, asking in the first place for a reduction of the duties on sugar to one uniform rate of 4s. 8d. per cwt. Antigua is not the place in which such a memorial might be expected to originate, and it appears, from voluminous correspondence in the island newspapers, that the planters there are by no means of one accord on the question—as will be seen by an extract from one of the letters on the subject:—

"I trust the planters of Antigua will pause before they sign a memorial, the effect of which, if granted, will be to hold out a heavy premium to the refined sugar of Cuba, the vacuum pan sugar of Demerara, and the beet-root sugar of France and Germany, by taxing these *at the same duty* as their own muscavado. The Committee decided that the duty should be levied as nearly as possible on the amount of *extractable saccharine matter* in the same way that the customs charge duty on rum—according to the quantity of alcohol it contains. Would the writer of the memorial propose that our Leeward Island rum of low proof should pay the same duty per gallon as the high proof rum of Demerara and Jamaica?—I trow not. Then why should he seek to tax pure saccharine at the same duty as our sugars, containing as they do, a large proportion of matter, not saccharine?

"The argument that the differential duties afford a premium for making bad sugar, is altogether fallacious. What it *does do*, is to allow the planter of small means who cannot afford to erect a refinery, or a vacuum pan, to enter the market on as nearly as possible equal terms with his richer competitor. Nor is the argument comparing tea with sugar a happier one, as every one knows, or ought to know, that common congou, at 10d., is as pure *tea* as souchong or pekoe, at 1s. 6d. or 2s., and, unlike muscavado sugar, is not combined with any *foreign matter*.

"The statement in the memorial as to the mode of assessing the duty, even if true, does not in any way affect the principle of a scale of duties. The science of the present day is quite capable of detecting the amount of saccharine matter in any sample of sugar, and I cannot imagine, if the present mode of assessing duties is so "vicious" as is described, how men of intelligence, as our merchants and brokers undoubtedly are, can submit to it. However, as I have said, this can in no way affect the principle, which is to tax the *saccharine* and not the matter with which it is combined in raw sugars.

"If the writer would separate his application for equalization, and apply only for reduction or abolition, he would have, I believe, the unanimous approval not only of this, but of every other West India sugar-producing colony."

"I am, sir,

"Yours respectfully,

"P. BURNS."

In some of the replies to Mr. Burns, and also in some remarks in a Barbadoes paper, the opinion is expressed that, if equalization of duties would be detrimental to some interests, total abolition would be much more so. It is scarcely needful to invoke the authority of Political Economy to confute this fallacy, the absurdity of which is apparent. With neither duties nor drawbacks, no one interest could possibly have any fiscal advantage over another; but a fixed duty would favour the foreign refiner at the expense of the producer of raw material, and in direct proportion to the amount of the duty; thus, at a fixed duty calculated to produce the same revenue as the present graduated scale—say 10s. per cwt.,—10 cwts. of loaf sugar would pay 100s., or 10s. for each cwt. of pure sugar; 10 cwts. of fine Havanna would equally pay 100s., and as 9 cwts. of pure sugar would be extracted from it, the duty would be about 11s. per cwt. of pure sugar; 10 cwts. of Muscavado would also pay 100s., this would yield 8 cwts. of pure sugar, which would thus pay 12s. 6d. per cwt. Manila, Jaggery, and other low sugar would of course pay proportionately more. It comes then to this—that on one uniform rate of 10s. per cwt., French beet-root sugar made into loaves would pay 10s. per cwt.; slave-grown Havanna, 20s. per ton more; and the produce of the island of Antigua, 50s. per ton more. But the buyer would simply buy the cheapest sugar for his money; the beet-root refiner would be protected, and the grower of low sugar injured, to the extent of the difference; and the ultimate but inevitable effect would be, that the Antiguan planter would have to sell his sugars at an average of 30s. per ton less than at present, a tax on the island of something like £20,000 per annum, from which the British consumer would not derive the slightest benefit, but which would be paid in the shape of higher prices, mainly to foreign refiners and producers of beet-root sugar. The principle is just the same whether the fixed duty be 10s. per cwt. or 5s.; and supposing Mr. Lowe could be induced to spare half the revenue from sugar, and fix it at 5s., the result would, in each case, be just half what is indicated above.

If, instead of asking for the reversal of the policy pursued on the sugar duties for so many years,—a policy approved by the most eminent modern statesmen and financiers—the Antigua memorialists had petitioned for their total and immediate repeal, their appeal would have had greater weight. All classes interested are in favour of *this* solution of the question; with freedom of trade no interest would be protected or injured, and without giving to our sugar colonies any fiscal advantage, it would greatly promote their prosperity, and strengthen the ties which bind them to the mother country.

STATE OF CUBA.

According to a correspondent of a New York paper, "the civil war in Cuba" has degenerated into a savage butchery.

It is said that eight thousand men are about to be sent to replace fourteen thousand Spanish soldiers, who have fallen through the casualties of war, or become victims of yellow fever and cholera; and that the same fate will probably befall the fresh reinforcements, for, according to the latest news from the more important points—as the isle of Satiago de Cuba, for instance—the yellow fever and cholera are making fearful ravages. The Cubans, it is stated, are prepared for all extremities, rather than submit longer to the yoke of Spain, as a proof of which, a proclamation of Cepedes, the chief of the insurgents, is cited, to the effect that, in order to deprive the Spaniards of the revenues derived from sugar and tobacco, he has ordered the destruction of the plantations of both of these. The writer adds that in proof of the prevalence of the "fanaticism of independence," which recalls the worst periods of the civil war in the United States, this order is being carried into effect—that the most beautiful plantations are being reduced to ashes—and that very shortly, if the Cubans are left to themselves, the Pearl of the Antilles will be nothing more than a vast desert.

This account, considering its source, must of course be taken *cum grano salis.* Nothing is less likely to promote the popularity of the insurrection amongst the influential class of Cubans than the mode of warfare above described; indeed, it may be taken (if the account is true) as a proof of the weakness of the insurrection, rather than of its strength.

From the Antigua Times.

Some time since we noticed the arrival of two steam ploughs in the island, and remarked on the occurrence as a proof of the progress of enterprise in Antigua. Since then another event has occurred which we think bears out still more fully what we said then. We allude to the importation by "Fryer's Concrete Company, Limited, of their fourth Concretor. This machine is, we believe, intended for the Belvidere estates, and will, from its size, nearly double the power of the factory there. It is of the largest style, with all the recent improvements; and its erection gives proof, if any were wanting, that the company is not likely to let either the cultivation of its own estates or the purchase of canes (of the benefit of which, to the small holder, we have before spoken) languish for want of a judicious expenditure.

PROSPECTS IN BARBADOES.

From a Letter, by S. T. Hardy, in the Reporter.—The sugar-crop of 1869 has indeed proved woefully short—considering the acreage under canes, (to say nothing of the expense of its preparation and manuring), and I suppose it has been the worst since the abolition of slavery in 1834, as regards the money realized by its sale. In hhds., putting aside small packages, the exports of 1869 are only 27,000 as against 51,000 hhds. the previous year; in fact, about half a crop. With our present extended system of planting, I believe there are 35,000 acres under canes every crop—less than 50,000 hhds. sugar, annually exported, will not "pay" at the ordinary price of sugar. The quality of Barbadoes sugar, in such a dry season as the last, is necessarily inferior to that produced from canes arrived at perfect maturity. We have found the quality of this year's shipments worse than for many years—as recent letters from the principal consignees have mentioned. The state of the English and American markets has, fortunately, enabled merchants to get out of this year's sugar at better prices than they obtained for the superior crop of 1867-8. This has helped us. Also the unusually large yield of molasses has found a very good market in the island with American buyers.

We are now approaching a new year and "the next crop." It is unnecessary to dwell on the nature of the growing season of 1869. I did hope early in June, when the country was looking well, and crops starting from a long lethargy began to grow vigorously, that, with favourable weather to the end of the year, we might find 50,000 hhds. exported in 1870. After so many hard knocks from the repeated spells of drought since then, I fear it is now only too probable we are in for another short crop as a whole, though I expect not a few plantations will do better in 1870 than in 1869.

As a community, we find ourselves now so much the poorer as compared with our position a year ago, that another short crop is a serious prospect; some say it is a calamity or judgment. Rather let us regard it as a timely warning—"a blessing in disguise." Here we are depending too much on one precarious and most uncertain plant, with a swarming and increasing population, and nature (so to say) has placed us in a position, in many important respects unrivalled, for attracting a goodly share of the trade of the world passing our shores.

There is, I think, too great imgortance attached to land-owning here, and, (as our late Governor pointed out in his "Blue Books,") a struggle for possession of land in our crowded island results in the giving of enormous prices, and a hand-to-mouth existence, when buyers have little capital. A 'rise in price' of sugar increases the evil, and our true interests seem to be that sugar should remain at an equable and moderate value. I should regret, therefore, to see prices rise any higher than the average of the present year.

FROM GOVERNOR RAWSON'S ADDRESS.—Ere long, Steamers will be established on all the main lines of commercial traffic over the face of the globe. Two lines now touch at Barbadoes. Two other lines, one connecting New York with South America, the other projected to connect the Dominion of Canada with British Guiana, are desirous of doing so. The establishment of telegraphic communication with Europe and North America, which will enable passing vessels in the Australian and South American trades to receive orders here, the first and most favourable point of the globe for that purpose, will open a new and vast field for the traffic of Barbadoes.

SORGHO SUGAR.

(From the American Grocer.)

MACON, GA., Nov. 17, 1869.

Among the articles on exhibition are four specimens of sugar made from the sorgho cane. The sugar is excellent. It ranges from white to brown. The importance of this matter cannot be over-estimated. For a long time the practicability of making sorgho sugar was in great doubt, and even after this was determined, it was in still greater doubt whether it would pay to do it. These matters are settled, and triumphantly settled, in favour of the sugar.

This sugar was made in Atlanta at the Sorgho Works of Glenn and Wright. We give the results of the working of this system of sugar making. One gallon of syrup will make from five to seven pounds of sugar, and leave a quart of excellent syrup. An acre of cane will give a hundred gallons of syrup, or from five to seven hundred pounds of sugar, and one hundred quarts, or twenty-five gallons of syrup. The sugar is worth 20 cents per pound, or 100 dols. for the 500 pounds. The syrup left is worth 1 dol. per gallon, or 25 dols. for the 25 gallons. Thus 125 dols. per acre gross is realizable from each acre of cane.

In South-western Georgia, planters have on the same quality of land made more money on their sorgho sugar than their cotton.

The South Carolina State Agricultural Society has recommended the making of this sugar by this plan to the planters of the South.

As the cane will grow all over the State, it will behove all of our farmers to look into this matter.

NEW PATENTS.—FROM THE MECHANICS' MAGAZINE.

1486. J. H. JOHNSON, Lincoln's Inn-fields. *Treatment of Beet-root.* (A communication.) Dated May 14, 1869.

The object is to provide a straining or filtering surface for the pressing cylinders used in treating beet-root, which shall not be liable to become clogged by the adhering thereto, or the accumulation thereon, of the solid or tenuous particles of the pulp, the openings being at all times perfectly permeable, whilst the juice itself is allowed to passed through them in a highly pure condition. This result is obtained by the use of a smooth metallic, filtering, or straining surface, that is to say, a surface presenting no rough parts to which the pulp can attach itself.—Patent completed.

1498. F. KOHN, Robert-street, Adelphi. *Extracting juice from sugar.* (A communication.) Dated May 17, 1869.

This consists in carrying out the whole process of diffusion in one single vessel or diffuser, in which the sugar extraction is carried on continuously by introducing the slices of cane, beet-root, or other plants through a feeding apparatus at the bottom of the vessel, from which they rise slowly and gradually to the top, while the fresh water is constantly running in at the top of the diffusion vessel, and is drawn off at the bottom as diffusion juice, after having remained in contact with the slices for a sufficient length of time.—Patent completed.

1511. W. R. LAKE, Southampton-buildings. *Drying sugar.* (A communication.) Dated May 17, 1869.

The time for drying sugar loaves in the ordinary manner is from eight to twelve days, but with this improved apparatus the time is reduced to twenty-four hours. This improvement is obtained by producing complete currents of heated air in the loaves themselves.—Patent abandoned.

FOREIGN PATENTS.—FROM "LA SUCRERIE INDIGENE."

84311. M. HANON A BETHUNE, Pas de Calais. *Apparatus for heating and evaporating liquids.*

This apparatus is composed of two concentric vases, the interior, which is open at the top, is fitted with two or more serpentines for the evaporation of the liquid. The second vase, which is closed at the top, envelopes the first on all sides, and receives in the space which separates them the vapour thrown off by the boiling liquid. This vapour, which escapes by a flue at the bottom of the vase, cannot reach this opening until it has traversed up and down five compartments into which the space between the two vases is divided. Into the first of these compartments the waste steam from the steam engine may also be turned.

84731. M. M. JUGL ET KODL, Austria. *Process of clarifying and purifying sugar in the moulds or other receptacles by means of the clearing syrup with high pressure either of air or water.*

The moulds for the loaves are placed as usual, but are provided with a ledge at the top,—the base of the cone—on this ledge is placed a covering which, by being screwed on a leathern washer, may be hermetically closed. There are two holes in this cover, one for the air tap, the other for an Indian-rubber tube, which conducts the clarifying syrup to the mould from a reservoir above submitted to the pressure of one atmosphere. Under the influence of this pressure the passage of the syrup through the loaf is very rapid, and the operation of clarifying only requires six hours at most. To accelerate the process of draining the loaves, for the ordinary "succettes," a current of compressed air from a reservoir is substituted—the pressure of *aspiration*. By a peculiar contrivance the air reaches the mould by the same passage as that by which the syrup was conveyed. Considerable pressure may be applied. The patent includes the provision of a steam-guage and a safety valve.

☞ "The Sugar Industry of Java," by J. Millard, Esq., will be continued in our next Number.

The Report of the Commissioners on the subject of Distillery Lees in British Guiana has been received, with thanks.—*Ed. S. C.*

STOCKS OF RAW SUGAR IN THE CHIEF MARKETS OF THE WORLD, IN THOUSANDS OF TONS, TO OCTOBER 31.

	1869.	1868.
United Kingdom	132	148
France	66	83
Holland	20	38
Zollverein	21	30
United States	101	55
Cuba	28	33
Total	369	387

CONSUMPTION IN EUROPE AND UNITED STATES, IN THOUSANDS OF TONS, FOR YEAR ENDING OCTOBER 31.

	1868-9.	1867-8.
Europe	1255	1180
United States	410	425
	1665	1605

SUGAR STATISTICS—GREAT BRITAIN.

To 18th Dec., 1869. In Thousands of Tons, to the Nearest Thousand.

	STOCKS.						IMPORTS.						DELIVERIES.					
	London.	Liverpool	Bristol.	Clyde.	Total, 1869.	Total, 1868.	London.	Liverpool	Bristol.	Clyde.	Total, 1869.	Total, 1868.	London.	Liverpool	Bristol.	Clyde.	Total, 1869.	Total, 1868.
British West India	8	1	1	3	13	33	89	9	13	44	155	196	101	11	14	48	174	186
British East India	13	5	..	..	18	9	20	7	..	..	28	9	12	6	..	..	18	10
Mauritius	2	..	..	1	4	8	8	1	5	5	19	40	12	1	5	5	23	39
Cuba	10	3	..	7	20	23	17	16	27	58	118	134	13	15	27	62	118	128
Porto Rico, &c. ..	3	2	..	1	6	5	6	13	2	3	23	18	6	13	2	3	23	18
Manilla, &c.	36	8	..	2	46	46	32	20	1	4	56	46	25	23	2	2	51	41
Brazil	..	8	1	3	12	22	1	33	16	16	66	62	2	41	16	17	76	56
Beetroot, &c.	2	1	..	1	4	3	16	5	1	15	36	40	17	4	1	14	35	42
Total, 1869 ..	75	26	3	18	122	148	190	103	64	145	502	546	187	114	66	151	519	519
Total, 1868 ..	76	40	4	29	26decrease		201	105	57	183	44decrease		192	103	59	166	slight decrease	

STATE AND PROSPECTS OF THE SUGAR MARKET.

During the past month the markets have been firm for most descriptions of raw sugar. A good business has been done, and rather higher prices have been paid for the better classes of goods. Refined sugars have been in good demand at former rates.

Notwithstanding the unprecedented crop of beet-root sugars—100,000 tons above that of 1868—and the probability of a largely increased supply of good sugars from Mauritius, considerable confidence is displayed, and a healthy tone prevails.

The long continuance of the insurrection in Cuba, the source of the supply of so large a proportion of good sugars, no doubt tends to the firmness of the market; and it may be noted that although the deliveries in the United Kingdom to the middle of December do not exceed those of 1868, yet on the Continent of Europe they are considerably in excess. The stocks of refined sugar, as well as of good raw are much reduced, which general deficiency, together with increased consumption, may fairly be set against any over production of beet-root sugars.

☞ *Communications and Advertisements to be addressed to the Editor of "The Sugar Cane," Galt & Co., Publishers, Manchester.*