U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN No. 27.

THE SUGAR-BEET INDUSTRY.

CULTURE OF THE SUGAR-BEET

AND

MANUFACTURE OF BEET SUGAR.

BY

H. W. WILEY,

CHEMIST.

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PREFATORY NOTE.

WASHINGTON, D. C., *May* 12, 1890.

SIR: I have the honor to submit herewith, for your inspection and approval, the manuscript of Bulletin No. 27 of the chemical division, entitled "The Sugar-Beet Industry."

Respectfully,

H. W. WILEY,
Chemist.

HON. J. M. RUSK,
Secretary.

INTRODUCTION.

During the past year the Department of Agriculture has received many hundreds of inquiries from all parts of the United States relating to the culture of the sugar-beet and the production of sugar therefrom. This growing interest in beet culture, together with the fact that all the previous publications of the Department concerning the sugar-beet are out of print, has led to the preparation of the present bulletin.

The object of this bulletin is to give, as nearly as possible, the present condition of the beet sugar industry of the United States; to locate, approximately, those portions of the country which are best suited for the production of the sugar-beet, and to indicate the line of work necessary to the successful introduction and extension of the beet sugar industry in this country.

In connection with the elaboration of the above plan, a résumé will be given of the publications of the Department on this subject, above referred to, and which are no longer accessible to the public. The principal publications, omitting the brief accounts published in Annual Reports which have been issued by the Department, are as follows:

(1) "Report on the Culture of the Sugar-beet and the Manufacture of Sugar therefrom in France and the United States," by Dr. Wm. McMurtrie; Government Printing Office, 1880, pages 294.

(2) "The Beet Sugar Industry of the United States," Bulletin No. 3, of the Chemical Division, pages 24 to 27 with 12 mean temperature charts.

(3) Bulletin No. 5 of the Chemical Division, Part Second, "Beet Sugar," pages 37 to 137, inclusive, with 12 plates.

In addition to the above publications, numerous articles, mostly abstracts of the above, have appeared in the Annual Reports, and a few pages of the bulletin entitled "Encouragement to the Sorghum and Beet Sugar Industry," issued in 1883 by the Department, were devoted to the sugar-beet.

It is evident that a work of this kind for the United States must be chiefly a compilation of the results obtained in other countries, since the industry here is so young that little is known of it from our own investigations. Nevertheless, a large quantity of material has been gathered during the past year relating to beet sugar in various parts of the United States, and this matter will also be incorporated in this bulletin. It must be understood that the object of this bulletin is not to give a complete treatise upon the culture of the sugar-beet and the manufacture of sugar therefrom, but simply to indicate in a general way, for the information of those interested, the general principles of this industry. One especial object which will be kept in view will be to prevent those intending to engage in this industry from going wrong in the beginning, and squandering their money and time in battling with problems which science has already met and overcome. It is further hoped that the careful perusal of the data which will be presented will prevent any mistakes from being made which would end in financial disaster and which are so apt to attend the early history of every industry.

There will probably be found for many years to come in the United States more enthusiasm than knowledge connected with the sugar-beet, and the result of this will be, unless great care be taken, that many ventures will be made which may result in financial disaster, disaster which could have been avoided by a thorough comprehension of the fundamental principles of the industry.

In so far as the manufacture of sugar from the matured beet is concerned we are able to start at the present time with the accumulated knowledge and experience of three-quarters of a century of investigation. So perfect have the processes of manufacture become that nearly all of the sugar which is stored in the beet can be secured in merchantable form and by comparatively inexpensive methods. By the term inexpensive, however, it must be understood that the actual processes of manufacture are denoted and not the cost of the machinery. The various processes for the extraction of the sugar from the beet, the best methods of clarifying the juice and of evaporating it and for separating the sugar from the molasses, are thoroughly well understood and are no longer legitimate subjects for public experiment. The great problem in this country is the agricultural one. The selection of suitable soil, the finding of the proper climatic conditions, and instruction in the method of planting, cultivating, and harvesting the beets, are all matters of vital importance. Without a careful study of these subjects, and without the proper knowledge thereof, it will be a hopeless task to introduce successfully the beet sugar industry into this country.

One of the great dangers to be avoided is the formation of hasty conclusions in regard to the proper localities for the production of the sugar-beet. Often without any study whatever of the climatic conditions or of the character of the soil, efforts are made to build large and expensive factories, which as often have to be abandoned on account of having been wrongly located. The studies which have been made heretofore in regard to climatic conditions have been of such a nature as to locate, in a general way, the areas in the United States suitable for the culture of the sugar-beet.

It has been found in general that the coast valleys of California, and probably large areas near the coast in Oregon and Washington, certain parts of the Dakotas and Nebraska, localities in Minnesota, Iowa, Wisconsin, and Michigan, parts of northern Illinois, Indiana, Ohio, and New York present favorable conditions for sugar-beet culture, but in the localities thus broadly intimated there are certain restricted areas most suitable to the sugar-beet, and it is only these restricted areas to which we must look for success. The fact that in one locality, for instance in Nebraska, good sugar-beets can be produced would be no warrant whatever for assuming that all parts of that State were equally suitable for this purpose, and this remark may be applied to every one of the States mentioned above.

Sugar-beets have also been raised in other localities in the United States, notably in New England, New Jersey, Delaware, and Kansas, and while there may be areas in the New England States where beets can be successfully grown, it must be admitted that the States last named stand in the second rank of beet sugar producing localities. In Kansas, during the last year, as will be shown in the body of this report, sugar-beets were grown and a considerable quantity of sugar manufactured therefrom. This, however, does not show that Kansas will be able to compete with more favorable localities in the production of beet sugar.

In general it may be said that the summers in Kansas are too hot to expect the production of a sugar-beet uniform in its nature and containing a high percentage of sugar.

If the sugar-beet industry is to succeed in this country this success must come from sharp competition with the same industry in older countries, where its conditions are better understood and where the localities suited to it have been selected by long and often costly experience. It must also compete with the sugar-cane industry, both of this country and of tropical countries, and for this reason we can only expect it to survive in those localities where soil and climatic conditions, proximity of fuel, cheapness of labor, and other favorable environments are found.

It is to be hoped that the mistakes which have so long threatened the sorghum sugar industry with destruction may be avoided with the sugar-beet. Calm judgment and sober reason must not give way to enthusiasm and extravagant expectations. All conditions of success must be carefully studied, all the difficulties in the way of success must be intimately investigated and allowed for, and ample capital, coupled with judicious perseverance, must be enlisted in its behalf.

Many attempts have been made for the past twenty-five years to introduce the beet-sugar industry into the United States. Factories have been located in the New England States, notably in Maine and Massachusetts, also in Delaware, in Illinois, and in California. With two exceptions all of these ventures have brought with them financial disaster. The factories in New England, Delaware, and Illinois, and some of those started in California have been abandoned. One factory in California has been very successfully operated for a number of years, viz, the one at Alvarado. Another one, viz, at Watsonville, has been in successful operation for two years. From the success of these two it is reasonable to infer that others must also succeed when the proper conditions are supplied. It is well, however, that just now, when there seems to be such an awakening in regard to beet sugar, a few words of warning should be spoken. Any further financial disasters would exercise a most depressing effect upon the advancement of the industry. These disasters are sure to come if attempts are made to erect factories in a short time in localities where the capabilities of the soil and climate are untried, with capital insufficient in amount, and under the direction of those unskilled in all the branches of the industry itself.

For the proper erection and completion of a beet sugar factory not less than twelve months should be allowed, and even in this time it can only be properly accomplished under experienced technical control. During the present month, March, 1890, letters have been received at this Department from persons who contemplate the erection of a factory during the present season to be ready for operation by October 1. The orders for the machinery for these factories have not even yet been placed nor the contracts for the building let nor arrangements made for growing the beets.

It is easy to see that if such a work as this is pushed forward it can only end in failure. In contrast with this I may cite the instance of another factory, which is now in course of erection, which was located after a whole year spent in studying the conditions of soil and climate and in the actual growth of numerous plots of beets, and for which the machinery was ordered fully a year in advance of the time when it was to be used. The success of such a factory is almost a foregone conclusion. It is to be hoped that all persons intending to invest in the beet sugar industry may follow the latter and not the former example.

1.

THE SUGAR-BEET INDUSTRY.

HISTORICAL.

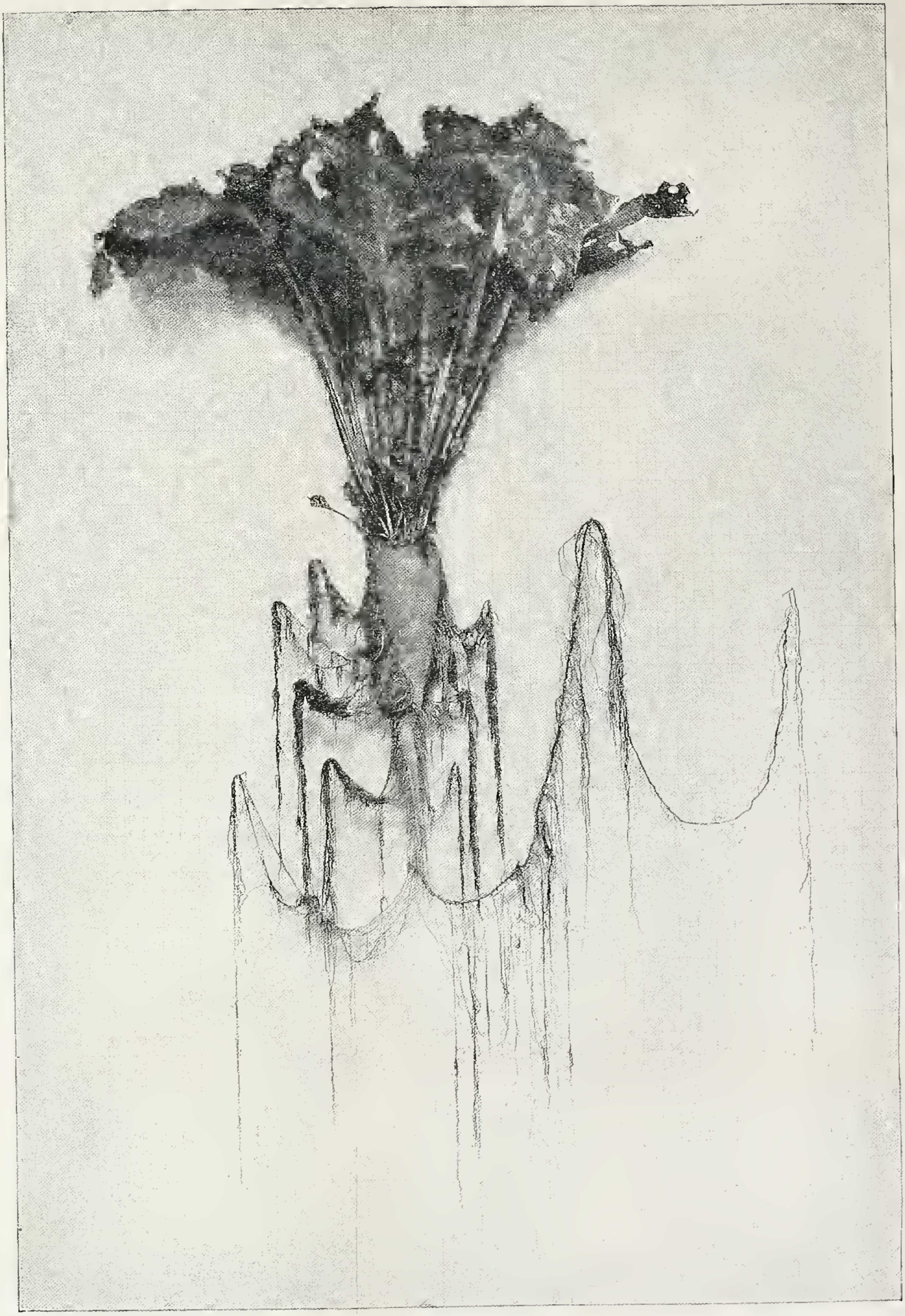
THE EARLY HISTORY OF THE SUGAR-BEET AND THE MANUFACTURE OF SUGAR THEREFROM.*

"It is difficult to trace the exact origin of this plant, which has become of so much interest and value in Europe, and is not only of national but also of continental importance to the people of the other side of the Atlantic. Its antiquity finds evidence in the fact that Theophrastus described two varieties: the deep-red, and the white beet. Olivier de Serres, in his writings in 1590, makes mention only of the red beet, and states that it had not long been introduced into Europe, and says that "the juice yielded on boiling is similar to sugar sirup." This variety was introduced in England in 1548, but the white variety was not known until 1570.

"According to the Abbé Rosier, four varieties were already known in 1782, the small and large red, the yellow, and the white. The variety known as *disette*, and which is still grown in France for feeding purposes, was believed to have originated in Germany. It was brought into notice by Vilmorin, the ancestor of the present head of the great seed house of Vilmorin-Andrieux & Co., who died in 1804, and was introduced by Perkins into England in 1786.

"The root does not seem to have been considered as having an industrial value, and was cultivated only for the table or for cattle food until 1747, when Margraff, a member of the Berlin Academy of Sciences, believing sugar to be a regular constituent of plants other than the sugar-cane, made examination of different varieties of vegetables, and succeeded in separating from several kinds varying quantities of crystallizable sugar. His method of research consisted in cutting the material to be examined into thin slices, rapidly drying it, reducing to fine powder, and exhausting with diluted alcohol. The results of his researches were announced in a memoir read before the Berlin Academy of Sciences, in the year above mentioned. Of all the plants examined, he found the beet to be the richest in sugar, and believing that Europe would find in this root the basis of an immense industry, he urged the importance of his discovery upon the Academy, hoping to see valuable

*Culture of the Sugar-Beet. U. S. Department of Agriculture. Special report No. 28. By Dr. William McMurtrie. 1880.



THE MATURE SUGAR-BEET.

Scale, ⅙.

and practical results follow it; but he was not destined to see his hopes fulfilled. His methods of work, which were at best imperfect, were of a nature to succeed only in the laboratory, and the prices of colonial sugars were so low as to render competition by the products from a new and untried source out of the question.

"This important discovery, therefore, remained dormant for nearly half a century, when one of Margraff's pupils, Karl Franz Achard, son of a French refugee in Prussia after the revocation of the celebrated edict of Nantes, and director of the Academy of Sciences of Berlin, again took up the line of research started by his preceptor, and finally succeeded in extracting sugar from the root on a comparatively large scale. The process he employed was peculiarly his own, and gave results which were at the time of an astonishing character. He announced his results in 1797, published his mode of operation, and in the latter part of 1799 presented a sample of his product, with a description of his method, to the Institute of France, stating that the cost of production of muscovado of good quality should not exceed 6 cents per pound. Achard's statements were as much the subject of doubt and even of severe ridicule by the people of his time as are the statements made by the Department of Agriculture in relation to sugar produced at the present time from sorghum and maize, and were even accepted with reserve by the members of the Institute of France, notwithstanding the high repute he enjoyed among his scientific *confrères*. The interest of the French Institute was so aroused, however, that a commission was appointed by that body to make an examination of the work of Achard and to repeat his experiments. The commission consisted of Cels, Chaptal, Darcet, Fourcroy, Guyton, Parmentier, Tessier, Vauquelin, and Deyeux. In their report they stated that Bermond had made unsuccessful experiments in the introduction of the culture of the sugar-cane in France, and the same was the result with the sugar-maple, for though the latter might possibly be grown it could never compete with the sugar-cane. Other plants had been experimented with; the turnip, carrot, parsnip, chestnut, stalks of maize, and many other plants were submitted to experiment, but, notwithstanding the assertions of certain enthusiasts, it was proven that none of these plants could supplant the cane, and that in spite of the sugar they were presumed to contain the experiments were unsuccessful. Such was the state of things when Achard made the announcement of his experiments and results.

"The commission then proceed to state that they had repeated the experiments of Margaff to determine the value of their roots, finding them to contain a little over 6 per cent. of sugar. They applied the method of Achard for extraction on a larger scale, repeated several times, and succeeded in obtaining only a muscovado of very brown color and disagreeable to the taste. This muscovado, however, was readily purified by means of alcohol, and in this way a sugar candy was obtained differing in no particular from that given by cane sugar.

"The conclusions arrived at were to the effect that if with Achard's process sugar may be extracted from the beet, the quantity was much less than that given by the alcohol process indicated by Margraff.

"They then modified the experiments by working on the juice of uncooked beets and obtained 25 per cent. more of muscovado; and as a final result of all their experiments they adopt as the cost of refined sugar about 18 cents per pound, but think this figure may be reduced by improved methods.

The report concludes as follows:

It results from what precedes:

(1) That it is certain that the beet which grows in France, and which may be recognized by its white flesh, traversed by red bands or rays, contains sugar as well as the same species grown at Berlin that Achard worked upon.

(2) That the sugar may be extracted by various processes, and acquire by aid of repeated purifications all the qualities of cane sugar.

(3) That the quantity of sugar which this root contains is so great that attention should be given to its extraction.

(4) If, as we are assured by Achard, we may, as it were, render this root richer in sugar at will by caring for its culture, it is desirable that experiments be made upon this subject.

(5) That independently of these experiments it would be of value to determine if, among the several varieties, some do not exist more rich in sugar than those pointed out by Achard.

(6) That, admitting the results of these experiments, it remains to be demonstrated that the beet may up to a certain point supplant the sugar-cane.

(7) That it is true to say that the cost of sugar can not be determined with rigorous exactness without knowing the results of operations made on a large scale. However, at the present time it may be presumed that this price would not be higher than that of cane sugar in ordinary times.

(8) Finally, if Margraff should justly be cited as being the author of the discovery of sugar in the beet, it must also be admitted that Achard is the first to have made fortunate application of this discovery, not only in announcing the favorable quantity that may be extracted, but also in pointing out the processes to which we could resort for success.

"Achard's appreciation of the action and conclusions of this commission may be gleaned from the following letter addressed to Citizen von Mons, and dated Berlin, November 16, 1800 (Ann. de Chem. 39, 223):

I thank you sincerely for sending me the interesting report of the Institute. I have noted with infinite pleasure that the researches made by the celebrated French chemists confirm my discovery. The differences found in the products as to the quantities and qualities result either from the culture of the beet or the variety chosen for the tests. Notwithstanding the objections of the commission, I am still of the opinion that the best method consists in boiling the roots before expressing the juice, the clarification then taking place within the cells themselves by the coagulation of the albumen, so that we obtain the juice entirely clarified, or better clarified than it is possible to attain from raw beets by the addition of blood or other coagulable substances.

"But the report of the French commission had the effect to dampen any enthusiasm that may have been aroused in France by the publication of Achard's announcement, and for the few years that immediately followed it no interest seems to have been manifested there on the subject.

"It was, however, otherwise in Germany. Achard's letter proves that his zeal was in no way abated, and other workers were eagerly following the new line of investigation and experiment now made so attractive by Achard; and Lampadius, professor of chemistry and metallurgy at the School of Mines at Freyburg, took it up, repeated the experiments of his eminent predecessor in the work, improved upon his methods, from the average results of which he estimated the cost of refined sugar would not exceed 18 cents per English pound, about the same limit established by the commission of the Institute. Hermbstaedt also, modifying the method of Achard, succeeded in extracting from 125 pounds of roots of *Beta vulgaris* 5⅓ pounds of brown sugar and 1⅞ pounds of sirup, which drained off. The Baron de Koppy, having interest and confidence in the methods and results of Achard, erected in 1805 upon his estate at Krayn, near the town of Strehlen, in Lower Silesia, works capable of the annual extraction of the sugar contained in about 525 tons of roots, besides the manufacture of the rum and vinegar resulting from the utilization of the wastes of manufacture, viz, the pulp and molasses. These works of Koppy were constructed after the designs furnished by Achard, and carried on according to the methods he had determined. Achard also erected a factory on his own estate at Cunern, near Steinau, on the Oder. The results obtained by these two enterprising pioneers in the beet-sugar industry were followed by the establishment of other works at Athaldsleben and near Augsburg, and the interest which had thus been aroused in Germany bid fair to be again communicated to the French. This was hastened by a letter of Achard to the editor of the Moniteur, and published in that journal of October 2, 1808. This so thoroughly explains his position, the character of his work, and the progress he had made since the report upon his former results, that we deem it of value to reproduce it here:

SIR: The manufacture of sugar in Europe being, in all its relations, and principally under existing circumstances, a very important object, I believe that you will not refuse to give publicity, in the Moniteur, to an exposé of the results of my researches upon the manufacture of sugar from the beet root, and the advantages which this new kind of European industry assures to all nations for which sugar is an exotic staple.

It was decided by the report given by the celebrated chemists, Cels, Chaptal, Fourcroy, Guyton, Parmentier, Tessier, Vauquelin, and Deyeux, under date of January 25, 1800, to the class of mathematical and physical sciences of the National Institute of France, upon the examination they made of my researches tending to the profitable extraction of sugar from beets—

A. That the beet contains sugar.

B. That the sugar may be extracted by different processes, and acquire by sufficient purification all the properties of cane sugar.

C. That even by following my first methods, which were still very imperfect at the time the celebrated French chemists were occupied with their varification, it was to be presumed that the price of beet-root sugar would not be higher than that of the cane in ordinary times.

D. That all doubts of the existence of sugar in the beet root and the possibility of extracting it being dissipated, it only remains to be desired that the experiments made on a larger scale may give to my work upon this object the degree of authenticity it merits.

Encouraged by the suffrage of so illustrious savants, I have labored during eight years to perfect the manufacture of sugar from beets by experimental researches made on a large scale in a factory I have established on an estate called Cunern, which I own near Steinau, in Lower Silesia. My labors have led to the determination of a much more profitable method for extracting the sugar from beet roots, so that by my new processes 25,000 kilograms (55,000 pounds) of these roots furnished 2,309 French pounds (2,098 English pounds) of unclayed muscovado, richer in pure crystalline sugar, in the relation of 662 to 591 than the brown muscovado of Jamaica, or 1,923 French pounds (1,748 English pounds) of a clayed muscovado richer in pure sugar in the relation of 666 to 664 than the white muscovado of Martinique, while by following my first imperfect methods the commission appointed by the Institute of France to repeat my experiments extracted and was able to extract from 25,000 kilograms (55,000 pounds) of roots, the product of 1 arpent of land (about 1 acre), only 782 pounds of muscovado (711 English pounds), containing 448 French pounds (407 English pounds) of pure sugar; that is, about one-third the quantity that may be extracted by aid of my new processes. The cost of production of muscovado from beet root according to my new processes, provided the extraction is carried on in a well-established factory, and the manufacturer secures his roots at the moderate price by growing them himself, as those in the colonies almost exclusively cultivate the cane, is compensated for as much by the leaves of the beets, which serve as food for cattle, as by the rum, other spirits, and vinegar extracted from the wastes of manufacturing the muscovado; that is, the pulp of the root exhausted of the juice which the press can remove, and the molasses.

The same being the case with the cane, it follows that sugar may be extracted with the same pecuniary advantage from the beet in Europe as from the cane in the islands. An arpent yielding, according to the basis determined by the French commission charged with repeating my first experiments, 25,000 kilograms of beets, from which is extracted by my perfected methods 2,309 and 1,923 pounds of muscovado, according to the quality given it, it follows that to produce 10,000,000 pounds of muscovado, it is necessary to set apart during the summer months only between 4,330 and 5,200 arpents of land to the culture of the beet. An area of this extent is too small to cause its use in the production of indigenous sugar to be followed by the restriction of other important cultures, and this is all the more true since it is necessary to set apart for the culture of the beet, as it is practiced in this province, only fields which have been used two years for the culture of spring and winter wheats and remain a third year in fallow without furnishing other products than the pasturage of cattle that are allowed to range upon it, and which is more than compensated for by the leaves of beets. The facts I have established in the preceding article are based—

A. Upon the report which the commission appointed to repeat my first essays in the extraction of sugar from the beet made in 1800 to the class of mathematical and physical sciences of the Institute of Sciences of France.

B. Upon the later official examinations of my manufacture of sugar at Cunern by my newly perfected methods and the results they have given, made by a commission appointed by the Prussian Government.

C. Upon the results furnished by a beet-root sugar factory established in this province according to my instructions by M. le Baron de Koppy on his place called Krayn, near the town of Strehlen. This establishment is adapted to the annual extraction of the sugar contained in 10,000 Silesian quintals or 577,500* kilograms of beets, besides the manufacture of the rum and vinegar which is obtained from the wastes of preparing muscovado, viz, the pulp of pressed beets and molasses.

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* 537 tons of 2,200 pounds.

The constant success with which the manufacture of muscovado established at Krayn has worked during three years, and the profit it assures its possessor, confirm the results presented by the official examinations which have been made of the manufacture of muscovado according to my perfected methods, so that it is perfectly proven :

(1) That the muscovado furnished by the beet root is of a quality equal to that of the cane.

(2) That the quantity of muscovado furnished by beet roots is found so thoroughly proportional to the cost of its extraction and the profits obtained from the waste products of manufacture in employing them for that of rum or other spirits of the better quality, and a very good vinegar, that these advantages under favorable local circumstances wholly, and under all circumstances in a great part, compensate for the cost of production of muscovado from beets, as is also the case with regard to the muscovado from the cane—the cost of extraction of which is more or less compensated for by the rum extracted from the waste products they leave.

(3) That the manufacture of sugar from beet roots may become the object of an important industry for Europe.

(*a*) By the very considerable sums it will save from exportation.

(*b*) By the means it will furnish a large number of persons of the indigent classes to procure subsistence in the manual labor it requires.

(*c*) By the independence in which, with regard to this staple, it places Europe and other parts of the world which are really the principal depositories.

(Signed)

ACHARD.

CUNERN, near STEINAU, LOWER SILESIA, 1808.

"The following article, from the Moniteur of March 2, 1811, will also be of interest in this connection, as corroborating the statements of Achard :

His excellency the minister of the interior, in making his report to His Majesty upon the sugar of beet roots, had hoped to be able to assure him that, according to the testimony of M. Deyeux, this sugar would present the double advantage of enriching those who entered into the manufacture and cost a price low enough for consumers.

But if M. Deyeux was unable to give this assurance on account of the fact that the main end of his work was in the interest of French speculators, to effect an improvement upon the processes of the German chemists, we may find it in the success already obtained in the establishment of the Baron de Koppy, success thoroughly recognized in Germany, and of which we have an eye-witness in M. Boudet, chief pharmacist to the army.

It will be remembered that M. Achard, chemist in Berlin, who first conceived the idea of making the extraction of sugar from beet roots an object of speculation and manufacture, announced in the Moniteur of 1802 the advantages of this sugar, which he procured by a process more perfect than that which four years before had not been unreservedly accepted by the Institute of France.

This number of the Moniteur having reached Breslau, capital of Silesia, and consequently in the neighborhood of the two factories said to exist in the province of Prussia, M. Boudet, being there at the time, considered it of value to verify the facts advanced by Achard, in order in case of need te be able to destroy or increase the impression which the article in the Moniteur may have produced in France. He accordingly betook himself to the house of Baron de Koppy, at Krain,* near the town of Strelzlen,* and visited the manufactory. He caused to be sent to M. Parmentier a memoir, an extract of which was inserted in the Bulletin de Pharmacie of the month of February, 1809.

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* In other places these are written Krayn and Strehlen.

We shall not dwell upon the interesting details into which M. Boudet entered to elucidate for his countrymen the means of establishing similar manufactories in Europe. It is sufficient for our purpose here to make known the profit obtained by Baron de Koppy from his own works at the time of the visit of M. Boudet.

He affirms (1) that Baron de Koppy is very well satisfied with the quantity of sugar, rum, spirits, and vinegar furnished by his beets, and with the ready and lucrative sale he had for these different staples; (2) that the culture of beet roots, far from diminishing that of wheat, contributed to procure for him more abundant crops than be obtained before, first, because in employing for beets only the lands formerly left to fallow, his wheat occupied the same area as before he thought of making sugar; and, second, because beets furnish, besides their sugar, a large mass of food for cattle and sheep. He was able, without enlarging his domain, to double the number of his cattle, to obtain more manure, and with the aid of this manure to obtain larger quantities of wheat. (3) He admitted that he owed to the existing war a large portion of the profits given him by a sugar the people were obliged to use in default of that from canes, but he asserted that should he in times of peace obtain from his factory only the cost of cultivation of the beets and the manipulation of the sugar, he would guard himself from abandoning it so as not to renounce the prosperity it had given him and which it could always preserve on his domain.

The sugar sold by Baron de Koppy was not refined. M. Boudet wished to know for himself if it was susceptible of being. The trial he made having succeeded, he thought this sugar would become that of the richer classes, at least until we have the sugar from grapes M. Proust had led us to hope for, the sirup of grapes having already replaced for the poor that of the cane.

The establishment of beet-sugar factories may therefore be undertaken with confidence throughout the empire; but we must observe, according to the memoir of M. Boudet, it is especially to the large proprietors that it will be profitable, and that they should content themselves with making raw sugar to be sent like that of the islands to the refineries, one of which is able to purify and convert into loaves the products of twenty factories.

"As Baron de Koppy admits in his statements to M. Boudet, the events which were brought about by the political conditions of the time did much to favor the success of the enterprise, for shortly after his works were started—in fact, in the years immediately following—Napoleon I issued his famous decrees of Berlin and Milan, establishing the famous continental blockade, and excluding from the markets and consumption all material whatsoever of English production or manufacture, and particularly the products of England's colonies. This, of course, made sugars scarce and dear, and enhanced the profits of the manufacture that Achard and Koppy had so opportunely developed.

"The same conditions stimulated the search for products indigenous to France that might be substituted for those colonial staples which had become articles of daily consumption, and the deprivation of which was most keenly felt, and sugar seemed to have claimed instant attention. But the source developed by Achard seems to have almost completely vanished from the thoughts of both scientists and practical manufacturers. The destruction of external commerce, of course, resulted in the downfall of the wine trade, and all eyes and all minds naturally turn to the utilization of the enormous crops of grapes France annually produced, and everybody seemed to look to the sugar this fruit contained, both as a substitute for the wanting colonial staple, and as the rescue from the ruin which appeared imminent to the proprietors of the vineyards, especially in the south. Parmentier was, among the scientists and members of the Institute, the leader of this movement and the promoter of this apparent germ of a new industry and internal source of national wealth, and he published a work entitled, "Traité sur l'art de frabriquer les sirops et conserves de raisin." The methods he indicated in this work were mainly followed in the experiments of 1808 and 1809, but were considerably improved upon by Proust and Fouques. They served, however, in the various southern departments of the empire, for the production of considerable quantities of sirup from the vintages of 1808 and 1809, samples of which were presented to the minister of the interior, who at once called the attention of the Emperor to the results represented in the samples in the following report, which will serve to show not only the condition of the enterprise at the close of 1809 and the beginning of 1810, but also what had been done previous to that time and the appreciation with which he regarded it; and the decree of Napoleon issued in consequence of this report will show the interest he had in this possible source of a substitute for the colonial staple. The report appeared in the Moniteur of June 23, 1810. The minister, Montalivet, says:

SIRE: I have reported to your Majesty the successes obtained by M. Parmentier, who has given very useful attention to perfecting grape sirup and making it suitable to replace cane sugar in many medical and domestic preparations. Your Majesty, who ordered it to be used in the palace, seemed satisfied with it. I desire to-day to fix your attention upon more important results. M. Proust, an able chemist, has extracted from grape sirup a concrete sugar. M. Fouques has found a means of bleaching it and giving it not only the brilliancy but also the consistency and color of cane sugar. I have called together a commission, composed of Messrs. Berthollet and Chaptal, Senators, and members of the Institute, Parmentier, Vauquelin, and Proust. The sugar of M. Fouques was submitted to them for examination. The commission decided that this substance was worthy of the highest degree of attention, and after having made some tests upon the substance itself, without any preparation, thought it especially essential to determine what would be its effects in different mixtures and different proportions. The commission then adjourned, and came together again at the ministry on the 12th of this month.

The commission found that conserves containing the triple and quadruple of grape sugar were too sweet. Those containing the double were less sweet than those containing a single proportion of cane sugar. That the grape sugar equivalent of cane was a little over 2½ to 1.

MONTALIVET.

"In consequence of this report of the minister of the interior, His Majesty issued, under date of June 18, 1810, the following decree:

ARTICLE 1. There is accorded the sum of 100,000 francs ($20,000) to M. Proust,* and one of 40,000 francs ($8,000) to Sieur Fouques, in the form of gratuity and by way of encouragement for the discovery they have made of grape sugar.

ART. 2. They shall be obliged to use these two sums to establish grape-sugar factories in that portion of our southern departments designated by our minister of the interior.

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* By decree of June 21, 1810, Napoleon appointed M. Proust, chemist, member of the Legion of Honor.

ART. 3. They shall be obliged to give up the secret of their processes, which shall be rendered public, and be sent to all the prefects of our grape-growing departments.

ART. 4. From January 1, 1811, at the latest, the sugar of grapes shall replace in all public establishments the sugar of canes.

ART. 5. Our minister of the interior shall recommend to the prefects to propagate and encourage the establishment of factories for either grape sirup or concrete grape sugar, so that in the coming year the inestimable advantages of this precious discovery shall make itself felt for the good of all our people and the interests of our commerce.

"The same commission to whom was submitted for examination the samples of sirup and sugar produced by Messrs. Proust and Fouques were directed by the minister of the interior to prepare detailed instructions upon the methods to be followed for the successful and profitable extraction of sirup and concrete sugar from grapes, and the result of the work they at once entered upon, a copy of which may be found in the Moniteur of August 25, 1810, was printed and distributed throughout the grape-growing departments of France, in company with the following circular letter to the prefects of those departments, under date of August 18, 1810:

MONSIEUR LE PRÉFÊT: His Majesty the Emperor desires to give an impulse to the manufacture of sugar and sirup from grapes, and he has ordered that there be prepared to this effect simple instructions indicating the best processes to follow. He wishes that the instructions prepared by the most celebrated savants, and generally distributed, may lead proprietors to make sirup and sugar for their own uses, and place manufacturers in the way of making it in the surest and most economical manner, and completely supplying the markets with products from the next vintage.

I send you several copies of these instructions. Be so good as to distribute them to your officers who will make the best use of them, and cause them to be printed in the journal of your department.

You must not content yourself with causing the description of the process of manufacture of sugar and sirup from grapes to be distributed to even the smallest communes; you shall stimulate the zeal of your officers; you shall promise and accord prizes to those who shall have made the most of sugar and sirup of the best quality. I will supply, upon your requisition, the funds you may dispose of.

I also invite you to immediately confer with directors of hospitals and other charitable establishments of your department, that they in turn may confer with farmers, proprietors, and pharmacist who may desire to make sirups and sugars, and arrange with these persons such markets as will assure the sale of the products of this year. You shall preside over these arrangements, and take care that, without injuring the interests of the poor, there may be all-sufficient encouragement for manufacturers.

You shall address to me a table of the quantities of sugars and ordinary sirups annually consumed in each hospital, and of the presumed consumption of the coming year in sirups and sugars of grapes, with indications of the markets which have been recorded.

The subprefects and mayors will, I hope, second you in all your efforts. You shall make known to me those functionaries and special persons who shall be most distinguished in this sphere of usefulness which is open to them. I shall report their efforts and their success, as well as your own, to the Emperor.

Let manufacturing establishments multiply everywhere. Let it be considered, M. le Préfêt, that this is a sort of war we are making against the enemies of the Continent, and which his Majesty considers, more than any other sovereign, worthy of recompense to those who make themselves prominent in the ranks.

COUNT MONTALIVET,
Minister of the Interior.

"Immediately after this the Emperor issued the following decree, ddate August 22, 1810:

Considering that the economical manufacture of sugar from grapes essentially influences the prosperity of agriculture and commerce, and desiring to give to this important branch of the industry a particular mark of our special protection, we have decreed and do decree as follows:

ARTICLE 1. On June 1, 1811, the sum of 200,000 francs ($40,000) shall be distributed among twelve establishments which shall have made the largest quantity of sugar from grapes.

ART. 2. The distribution shall be made among the twelve establishments proportionally to the quantity of sugar that each one shall have made.

ART. 3. To secure the right of competition it shall be necessary to have made at least 10,000 kilograms (22,000 pounds) of sugar.

ART. 4. The quantities of sugar made shall be verified by a commissioner appointed for that purpose by the prefect of the department and certified to by the mayor of the place.

ART. 5. The prefect shall address these evidences to our minister of the interior before May 1, 1811. He shall also send at the same time a sample of the sugar made.

ART. 6. Our minister of the interior shall make to us a report to this effect. He shall make known to us at the same time the manufacturers who have perfected the processes of manufacture and shall propose to us the recompenses and encouragements they shall have merited.

"But while these encouragements were being given to the enterprise of producing sirup and sugar from grapes in the south to replace the colonial staple in the home consumption of France, the results of Achard's later work, as described in his letter to the editor of the Moniteur in 1808, had awakened anew the interest in the beet root as a source of sugar in the north, and M. Deyeux, reporter of the first committee of the Institute, which conducted the experiments of 1800, in compliance with a request made through the Institute by the minister of the interior, again undertook to repeat in 1809 and 1810 the experiments of the former committee, and the later work of Achard, with such modifications as he deemed advisable and practicable. In this work he was associated with Mr. Barruel, chief of the chemical department of the School of Medicine of Paris, and their labors were rewarded by the production of a certain quantity of muscovado, which they refined and thus secured 'two loaves of sugar, perfectly crystallized, of great whiteness, brilliant and sonorous, in a word enjoying all the properties of the finest cane sugar,' one of which was presented by the minister of the interior to the Emperor, who is said to have 'received it with that benevolence which he accords to every useful object.' But these experiments, while they showed the practicability of extracting sugar from the beet root by the means proposed, were still not of a character to show the net cost of producing the sugar, because the experiments viewed the work only in a chemical sense. Messrs. Barruel and Isnard then undertook to determine this part of the question, and repeated these experiments just mentioned, keeping strict accounts of the cost of each stage of the processes applied and the quantities of the products obtained. It was found that by their processes they were able to extract 1.5 per cent. of muscovado, which cost 30 cents per pound. The refined sugar produced from this lower grade cost 40 cents per pound. It appears, however, that the beets treated, which were grown upon the highly manured lands of the plain of Vertus where their works were located, were very unfavorable to the results of the experiments. It also appears that these figures represent the actual cost to the experimenters in the extraction of the sugar, taking no account of the by-products and assigning the maximum price for the beets worked; but the further estimates of cost made up by Messrs. Barruel and Isnard, based upon their own experiments and working by their own processes, supposing the value of the beets to be the actual cost of producing them and the amount of roots handled to be the yield of about 400 acres of land, about 6,000 tons, show that the cost of production should not exceed 8 cents per pound for good muscovado, or 12.9 cents per pound of refined sugar.

"The actual condition of the sugar enterprise in France at the close of 1810 may be gleaned from the following report to the Emperor by Montalivet, under date of January 10, 1811.

The production of sirup and sugar from grapes ordered by your Majesty is pursued with activity; and even though the season has not been very favorable to the vine, I am in daily receipt of proofs of the zeal with which a large number of proprietors are animated in the different departments, but those of the south and the center are the only ones who may engage in this manufacture, and on this account I would respectfully submit to your Majesty the results which lead us to hope that even the departments of the north may find upon their territory a sugar of very good quality. We know that for some years back beet-root sugar has been manufactured at Berlin and Breslau. Messrs. Achard and Koppy addressed to my predecessor very beautiful specimens of this sugar, but up to the present but slight results have been obtained. M. Deyeux, first pharmacist to your Majesty and member of the Institute, has just re-undertaken this work and has obtained very remarkable success in the results which he has addressed to me, and which I submit to your Majesty. He has also addressed to me an interesting memoir in which he has reported to the Institute the processes he employed to arrive at his results. He believes these processes to be more simple and better than those adopted by Messrs. Achard and Koppy. But M. Deyeux, obliged to devote himself to trials and experiments to find a good method, is unable as yet to establish the price at which this sugar can be produced. Everything shows, however, that this price will be sufficiently low to prove a large source of profit to extended manufacture. Already, in the department of the Doubs, a rich proprietor, Mons. Secci, has established a manufacture of this kind and has sown 80 acres in beets, which have yielded him 500,000 kilograms (500 tons) of roots, from which 25 to 30 milliers (27,500 to 33,000 pounds) of refined sugar may be expected. The prefect of Mont Tonnère has also informed me that Mons. Molar, a proprietor in his department has sown 80 hectares (197.6 acres) of ground in beets which he proposed to convert into sugar, and for which operation he asks to be admitted to the prizes which your Majesty has deigned to promise to manufacturers of sirup and sugar from grapes. In the department of Roer, the manufacturer of sugar from beet roots is carried on by the brothers Herbem at Urduiger. The prefect of the Rhine and Moselle has transmitted to me samples of a very fine cassonade from beet roots, manufactured by Mons. Anthonin, who asks for encouragement to enable him to enter upon this manufacture on a large scale. Finally, for Holland, the prince governor-general has sent me a sample of beet-root sugar made by M. Linden at Hemmer, in whose labors he appears to have confidence; and the prefect of the Bouches-du-Rhone has shown me samples of beet-root sugar made by M. Vanrroggen, one of his officers.

I shall, at a later date, report to your Majesty the results which these different attempts promise. At this time, I confine myself to presenting the sugar made by M. Deyeux. It in no way differs from the refined sugar of the colonies. This test shows what may be expected from this work as regards the quality of the material. I shall now study carefully the means of determining to what extent this manufacture may become economical and the measures to be taken to render it general in the departments of the north.

MONTALIVET,
Minister of the Interior.

"It is to be remarked further that prizes were also offered by the Société d'Encouragement pour l'Industrie Nationale for the production of sugar from grapes or beets, the annual prize being 2,400 francs ($480) for the best essay and sample, 1,000 francs ($200) for second best, and, on February 20, 1811, it received, through its founder and then president, Count Chaptal, a memoir upon the methods for the extraction of sugar from beets, by M. Drappiez, a pharmacist at Lille, together with a loaf of the sugar, of which he had been able to obtain 50 quintals by the method he described. The committee on chemical arts of the society compared the sample submitted by M. Drappiez with a sample of refined cane sugar they were then able to obtain at a cost of 95 cents per English pound, and failed to detect the "*slightest difference*" between them. M. Drappiez obtained by his method a yield of 1.3 per cent., the cost of which he estimated at 80 cents per pound.

"Shortly after this there appeared in the Moniteur of March 23, 1811, a statement to the effect—

That there had been presented to his Majesty several quintals of refined crystallized beet-root sugar, having all the qualities of that of the cane; loaves of both kinds have been mixed together, and it was impossible to distinguish between them. It follows from the report of a commission charged with the examination of the different means proposed to replace by indigenous processes the foreign productions so costly to France, that 70,000 acres cultivated in beet roots would furnish the 30,000,000 of pounds necessary to our consumption.

"And two days later Napoleon issued the first decree, in which he provided for direct encouragement of the beet-sugar industry, and which was as follows:

PALACE OF THE TUILLERIES, *March* 25, 1811.
NAPOLEON, *Emperor of the French, etc.*:

Upon a report of a commission appointed to examine the means proposed to naturalize, upon the continent of our empire, sugar, indigo, cotton, and divers other productions of the two Indies:

Upon presentation made to us of a considerable quantity of beet-root sugar, refined, crystallized, and possessing all the qualities and properties of cane sugar:

Upon the presentation made to us at the council of commerce of a great quantity of indigo, extracted from the plant woad, which our departments of the south produce in abundance, and which indigo has all the properties of the indigo of the two Indies:

Having reason to expect that by means of these two precious discoveries our empire will shortly be relieved from an exportation of 100,000,000 francs ($20,000,000) hitherto necessary for supplying the consumption of sugar and indigo:

We have decreed and do decree as follows:

ARTICLE 1. Plantations of beet root proper for the manufacture of sugar shall be formed in our empire to the extent of 32,000 hectares (79,040 acres).

ART. 2. Our minister of the interior shall distribute 32,000 hectares among the departments of our empire, taking into consideration those departments where the culture of tobacco may be established, and those which from the nature of the soil may be more favorable to the culture of the beet root.

ART. 3. Our prefects shall take measures that the number of hectares allotted to their respective departments shall be in full cultivation this year, or next year at the latest.

ART. 4. A certain number of hectares shall be laid out in our empire in plantations of woad proper to the manufacture of indigo in the proportion necessary for our manufacture.

ART. 5. Our minister of the interior shall distribute the said number among the departments of our empire, taking into particular consideration the departments beyond the Alps and those of the south, where this branch of industry formerly made great progress.

ART. 6. Our prefects shall take measures that the number of hectares allotted to their departments shall be in full cultivation next year at the latest.

ART. 7. The commission shall, before the 4th of May, fix upon the most convenient places for the establishment of six experimental schools for giving instruction in the manufacture of beet-root sugar conformably to the processes of chemists.

ART. 8. The commission shall also, before the same date, fix upon the places most convenient for the establishment of four experimental schools for giving instruction upon the extraction of indigo from the lees of woad according to the processes approved by the commission.

ART. 9. Our minister of the interior shall make known to the prefects in what places these schools shall be formed, and to which pupils destined to this manufacture should be sent. Proprietors and farmers who may wish to attend a course of lectures in the said experimental schools shall be admitted thereto.

ART. 10. Messrs. Barruel and Isnard, who have brought to perfection the processes for extracting sugar from the beet root, shall be specially charged with the direction of two of the six experimental schools.

ART. 11. Our minister of the interior shall, in consequence, cause to be paid the sum necessary for the formation of the said establishments, which sum shall be charged to the fund of 1,000,000 francs ($200,000) in the budget of 1811 at the disposal of the said minister for the encouragement of beet-root sugar and woad indigo.

ART. 12. From the 1st of January, 1813, and upon a report to be made to our minister of the interior, the sugar and indigo of the two Indies shall be prohibited, and considered as merchandise of English manufacture or proceeding from English commerce.

ART. 13. Our minister of the interior is charged with the execution of the present decree.

"Early in the following April, 1811, Decostils, reporter of the committee on chemical arts of the Société d'Encouragement pour l'Industrie Nationale, reported upon a memoir and results presented by M. Derosne. He was the first to suggest the use of quicklime in the purification of the juice. His method was based upon three principal points: (1) The use of caustic lime; (2) the use of alum; and (3) the use of alcohol. The lime he adds to the fresh juice, of which he succeeded in expressing 63 per cent. the weight of the root. The proportion added was 0.24 gram per liter of juice. After the addition of lime in a thick milk the juice was rapidly brought to boiling and the scums removed as they formed. The juice was then separated from the sediment, which settled and concentrated. It was then purified with alum and blood, and further treated in the usual way. The proportion of sugar extracted by this method is stated to have been 4½ per cent., and was the highest result that had yet been attained. The beets from which this high yield was obtained were of the white Swedish variety, while the beets of the plain of Aubervillier did not yield as much by 2½ per cent.

"After the announcement of this method of Derosne it appears that little was published on the subject of the new industry, that was now beginning to assume important dimensions, until the beginning of the following year, when Montalivet reported to His Majesty that 6,785 hectares (16,758 acres) had been sown in beets in different departments of the empire, producing 98,813 tons of roots.

"The number of factories established was thirty-nine or forty, and the minister estimated that if the whole product were worked up the result would be 1,500,000 kilograms (3,300,000 pounds) of sugar; but the plantations were in many cases too far removed from the factories to make it possible to transport the roots with profit. He also gave a table showing the number of hectares sown in beets in each department, the quantity of roots harvested, and the reasons which prevented more extensive planting in each. The latter seemed to be principally lack of sufficient seed and lateness of the season.

"About the same time a report was made to the Emperor by Count Chaptal showing the cost, by the methods then known and in use, of the culture of the beet and the manufacture of sugar. The first he estimates at 176 francs per metrical arpent (about $35 per acre), the yield of which varies from 12,000 to 45,000 to 50,000 pounds. The second cost he estimated at 15 cents per pound, supposing all the molasses to be sold; but if no molasses be sold then he estimates that the cost would reach 30 cents per pound. For the cost of refined sugar he makes two estimates; the first supposing 15 cents per pound as the value of the raw sugar, and in the second he values it at 30 cents. According to the first supposition the cost would be 32 cents per pound, and 45½ cents according to the second supposition.

"In concluding his report, Chaptal says an intimate knowledge of chemistry is necessary for successful work; and he recommends, as a means for assuring the prompt prosperity of this enterprise, that there be established at one of the factories already established a normal school, and that there be brought together there thirty or forty young men already versed in chemical knowledge, and forty others taken from among the children of refiners of Orleans, Antwerp, Ghent, Marseilles, Nantes, Amsterdam, etc., and from among the chiefs of refineries in the larger towns; and the establishment at which, it seemed to him, such instruction as he referred to could be given was that of M. Barruel, in the plain of Vertus.

"On the 12th of January, 1812, M. Barruel published a note upon the manufacture of beet-root sugar, and describes the method he had finally devised for extracting the sugar, and in this description we find the first mention of the use of carbonic acid for separating the excess of lime remaining after purification of the juice. He proceeds as follows: The juice is heated to 65° R.; milk of lime is then added (295 grams quicklime per 100 kilograms of juice, or 295 parts in 100,000); the whole stirred thoroughly and heated to 80° R. The coloring matter, etc., forms in soluble compounds and makes a flocculent precipitate. A solid scum forms on the top. The latter is skimmed off and the liquid decanted. The clear juice is then freed from lime, and for this purpose an acid which forms an insoluble compound with the lime is the best, sulphuric or carbonic acids preferred. Alum may be used according to Derosne's method, but this only acts by the sulphuric acid it contains, and while for equal weights sulphuric acid costs more than alum, it will neutralize more of lime.

"M. Barruel considers, however, that carbonic acid is the most economical of all, and for his purpose he prepares it by passing air through burning coals.

"In the conclusion of his note he says: 'This process, which is very simple and not costly, always succeeds. I guaranty its exactness and success.'

"Maumené states that about this time Napoleon visited a factory at Passy, where Benjamin Delessert had succeeded in producing white sugar from beets, and after having given him the cross of the Legion of Honor (the same which ornamented his own breast) as a recompense for this splendid initiative, the Emperor caused to be inserted in the Moniteur of the following day the grand evolution that had been consummated in French commerce. But of this circumstance we are unable to find any record in the Moniteur or the Journal de l'Empire of that period.

"On January 15, 1812, Napoleon issued the following decree, in all probability a result of the report made by Count Chaptal:

Section I.—School for manufacture of Beet-Root Sugar.

Article 1. The factory of Messrs. Barruel and Chappelet, plain of Vertus, and those established at Wachenheim, department of Mont-Tonnère, at Douai, Strasbourg, and at Castelnaudary, are established as special schools for the manufacture of beet-root sugar.

Art. 2. One hundred students shall be attached to these schools, viz: Forty at that of Messrs. Barruel and Chappelet, and fifteen at each of those at Wachenheim, Douai, Strasbourg, and Castelnaudary; total, one hundred.

Art. 3. These students shall be selected from among students in medicine, pharmacy, and chemistry.

Section II.—Culture of Beets.

Art. 4. Our minister of the interior shall take measures to cause to be sown throughout our empire 100,000 metrical arpents of beets. The conditions of the distribution of the culture shall be printed and sent to the prefects previous to February 15.

SECTION III.—MANUFACTURE.

ART. 5. There shall be accorded throughout our entire empire five hundred licenses for the manufacture of beet-root sugar.

ART. 6. These licenses shall be accorded of preference—

To all proprietors of factories or refineries.

To all who have manufactured sugar during 1811.

To all who have made preparations and expenditures for the establishment of factories for work in 1812.

ART. 7. Of these licenses there shall be accorded of right, one to each department.

ART. 8. Prefects shall write to all proprietors of refineries, in order that they may make their submissions for the establishment of the said factories at the close of 1812. In default on the part of proprietors of refineries to have made their submissions prior to March 15, or at the latest April 15, they shall be considered as having renounced the preference accorded them.

ART. 9. Licenses shall include an obligation on the part of those who shall obtain them to establish a factory capable of producing at least 10,000 kilograms (22,000 pounds) of raw sugar in 1812–'13.

ART. 10. Each individual who, having received a license, shall have actually manufactured nearly 10,000 kilograms of raw sugar resulting from the crop of 1812 to 1813 shall have the privilege and assurance, by way of encouragement, of being subject to no tax, or *octroi*, upon the product of his manufacture for the space of four years.

ART. 11. Each individual who shall perfect the manufacture of sugar in such a manner as to obtain a larger quantity from the beet, or who shall invent a more simple and economical method of manufacture, shall obtain a license for a longer time, with the assurance that no duty nor *octroi* shall be placed upon the product of his manufacture during the continuance of his license.

SECTION IV.—CREATION OF FOUR IMPERIAL FACTORIES.

ART. 12. Four imperial beet-sugar factories shall be established in 1812 under the care or our minister of the interior

ART. 13. These factories shall be so arranged as to produce with the crop of 1812 to 1813, 2,000,000 kilograms of raw sugar.

"We find one of the practical results of this generous decree in the announcement made by Charpentier *frères* of Valenciennes, Departement du Nord (Journal de l'Empire, of December 2, 1812), that they had for sale 12,000 kilograms (26,400 pounds) of beet-root sugar manufactured from the crop of that year, and during the first two months of work. The large quantity of beets they still had in store assured them, it was stated, for the end of April, 1813, a product of 60,000 kilograms (132,000 pounds), which they offered to sell as it should be made.

"But these results are more fully described by the minister of the interior, in his report upon the situation of the empire in the beginning of 1813, in which, under the head of new industries, he says:

To replace in our consumption the sugar, indigo, and cochineal of the colonies; to find in the south of Europe and at home the cottons and soda to supply our manufactures seemed impossible. It was ardently wished for, and the impossibility disappeared before our efforts.

During this year the manufacture of sugar which is extracted from the beet root will give us 7,700,000 pounds of this staple. It is prepared in three hundred and thirty-four factories, all of which are in actual activity.

After numerous trials, processes are finally employed by which beet-root sugar will not cost more than 15 cents per pound to the manufacturer. Mr. Bonmatin, inventor of this new method, profited by the useful labors of his predecessors, and the government, in order to hasten the fortunate results of his discovery, charged him to proceed to propagate it in those sections in which the principal manufactories are established.

Since the establishment of the high price of sugar, consumption has greatly decreased, and the 7,000,000 pounds manufactured at this time may be considered equal to at least one-half our actual needs. This diminution is not the result of any absolute privation that may have occurred, but from the equivalents by which sugar has come to be replaced.

Several millions of pounds of sirups from grapes and honey, the latter better purified and more abundant, have been substituted for sugar in a great portion of the domestic uses with so much of ease that the most delicate taste could scarcely perceive the change.

When the difficulty of procuring sugar and its cost shall be less; when the first profits, at present so great, if they be considered only as interest upon capital, shall have covered the cost of establishing, the quantity that will be consumed will again increase, the equilibrium will be renewed, and supposing that one-fifth the consumption to remain definitely replaced by sirup of grapes and honey, France will consume 40,000,000 pounds of beet-root sugar, the value of which will be 30,000,000 francs, and we may count upon these results for 1814. Our refineries now yield a product of 10,000,000 pounds, which will increase to at least 20,000,000 pounds.

In the six years beginning with 1802, we received from abroad an annual average of 52,000,000 pounds of sugar. During the four years beginning with 1809, the average annual importation has been but 10,000,000 to 11,000,000 pounds. It is especially since that time that nothing has been neglected to naturalize this staple at home, and the conquest is finally assured.

"But while all this interest and busy enterprise was being manifested in France, great progress was also being made in Germany. And the generous and worthy action of Napoleon in extending substantial encouragement to the development of the growing industry which produced such happy results had even been anticipated by the German Government, which came to the aid of Achard, who had for nearly fifteen years devoted all his time and limited means to the development and establishment of the industry, in the ultimate success of which, in spite of all the reverses to which he had been subject, he had never lost faith. His influence and example had led to the establishment of the works of Baron de Koppy at Krayn, and his watchful care over it had assured its financial success. And this besides those already mentioned was followed by the establishment of works in other sections, notably by Baron von Lorentz, Counselor Mengen, and more especially the Messrs. Mayer, of Breslau, who, we are told by Isnard, director of the special school of chemistry for beet-sugar manufacture at Strasburg, had for ten years sown about 750 acres in beets. In view of the progress attained and the interest manifested, the governmental authorities accorded to Achard, during the course of 1810 and 1812, the encouragement and aid indicated in the following notice sent by Achard to the Moniteur, and published in that journal, June 23, 1812, showing also the progress this pioneer in the industry had made. He says:

The public has, during the past year, been informed, as much by the decrees of the regency of Silesia as by the several writings I have published, that His Majesty, the

King of Prussia, has ordered me to establish on my two estates of Upper and Lower Cunern, near Wohlen, in Lower Silesia, a practical school for instruction as complete as possible, to make known to our people as well as to foreigners the processes employed in the extraction of sugar from beet roots.

"He further states that he had three distinct methods for extraction, using neither lime, carbonate of lime, milk, sulphuric acid, nor alum, except for beet of poor quality, or toward spring when vegetation has commenced. By the new method he succeeded in getting concrete sugar in twenty-four hours. The three methods of separating the sugar from sirups of beet juices are: (1) by regular crystallization; (2) by granulation; (3) by immediate conversion into bastard sugar. By the first method 1 quintal of juice gives 5 Silesian pounds of sugar. By the second 6 pounds are obtained, and by the third method, which is preferable to all others, the sugar may be extracted in twenty-four hours, yielding 5 pounds of raw sugar.

"This notice of Achard is followed by one from the Royal Regency of Silesia, upon the establishments of Achard, stating that—

His Majesty the King of Prussia, in giving to M. Achard a considerable sum of money, prescribed that he should establish and maintain upon his estate, and at his own cost, a factory for instruction in the manufacture of sugar from beets.

In the month of December of last year (1811), Achard having announced to the Royal Regency that he had established two factories—one factory on a small scale and such as could be united with farm management, the other to manufacture sugar on a large scale; that the building for lodging students was finished and ready to receive them; that the course of instruction would commence in January; and that he would be flattered to see an official examination of his work—we consequently appointed for this purpose two intelligent persons, who found that the buildings intended for the manufacture were actually completed, and provided with the apparatus and machinery necessary. It also appears from this report that since January 12 (1812) the manufactory has been in full activity, and that besides the students there were employed in the factory a foreman, nine male, and four female laborers. During the course of instruction 20 quintals are worked upon daily. Five pounds of raw sugar per quintal [110 pounds] are extracted, and, according to exact calculations made at the factory, it follows that 100 quintals of beets give a net profit of something more than 111 thalers current money.

"This model factory and school of Achard attracted students from nearly all the nations of the continent, and it is probable that it was the students he had from Russia who carried back to their country the germs of this industry, which has now become so powerful there, and which in that country received its establishing impulse through the aid and encouragement extended by the imperial authority; for it is related that General Blankenagel, who founded a factory in the government of Toula, at the village of Akabef, had received from the Czar of Russia a gift of 50,000 roubles ($38,895), and that an ukase or edict of the emperor gave the assurance that all lands of those establishing sugar factories should be free from tax.

"Such, then, was the progress attained in this new and valuable industry, and its condition in the beginning of 1814, during which memorable year what had bid fair to be a great source of national wealth and prosperity to all the continental nations received almost its death-blow. The beginning of the war with Russia interfered with its progress in that country. The destructive passage of foreign and contending armies destroyed completely not only this, but other and more flourishing industries in Germany, and the final conflict on French territory and the downfall of Napoleon, who has been described as the second father of the industry, resulted in its almost complete extinction in France, and the withdrawal on the part of the immediate successor of the great Emperor of the encouragement he had accorded was nearly as disastrous as had been the malicious depredations which were perpetrated by the enemy's troops, and it required the patient labor of more than another decade to accomplish what Napoleon had been able to establish in about one-third that time.

"But it must not be supposed that this new enterprise, which had assumed such formidable proportions, was during its development favored with a constant belief of the entire people of all nations in its value and its efficacy to supply a substitute for the staple of the tropical climes, which had formed the basis of much of the maritime commerce of the time. If Achard received ridicule at home and was looked upon by many of his countrymen as an insane enthusiast, but which prejudice by presentation of substantial evidences he was able to dissipate, the criticisms heaped upon Napoleon were of the bitterest character abroad, and the mutterings which could not under imperial rules enjoy unrestrained expression were not unknown to him, nor did they in any way affect the firmness of his resolution or his charity toward his critics at home, as is shown in the following address he made to the chamber of commerce March 11, 1811, in which he says:

The Berlin and Milan decrees are the fundamental laws of my empire as regards neutral commerce. I consider the flag an extension of territory, and the nation which suffers it to be violated shall not be considered neutral.

The fate of American commerce shall soon be decided. I will favor it if the United States will conform to these decrees; on the contrary, their ships will be excluded from my empire.

Commercial relations with England must cease. I proclaim it to you, gentlemen, distinctly. Merchants who have transactions there to settle or funds to withdraw should do it as quickly as possible. I gave this advice some time ago to the merchants of Antwerp, and they have profited by it.

I wish for peace, but not a patched-up one. I wish for it sincerely, and for such an one as will afford me sufficient guaranties, for I have not lost sight of Amiens or St. Domingo, or the losses which commerce sustained from the last declaration of war.

* * * * * * *

I have a knowledge of what is passing in the counting-houses of merchants. I know they denounce in high terms my measures and say I am badly advised. I will not blame them for their impressions, because, not having a view of the whole ground, they have not an opportunity to calculate and judge as I do. Nevertheless, those who have lately arrived from England will inform you of the injurious consequences produced in that country from an interruption of their commerce with the Continent, and may say it is possible I am right and that my designs may be accomplished.

* * * * * * *

I am informed that from late experiments France will be enabled to do without the sugars and indigoes of the two Indies. Chemistry has made such progress in this country, that it will possibly produce as great a change in our commercial relations as that produced by the discovery of the compass. I do not say, gentlemen, that I do not wish for maritime commerce or colonies, but it is proper to abandon them for the present, and until England shall return to just and reasonable principles, or until I can dictate to her terms of peace.

* * * * * * *

I know the English have better admirals, and that is a great advantage, but by often fighting them we shall learn to conquer.

* * * * * * *

The vent of colonial produce upon the Continent being once firmly shut, the English will be obliged to throw into the Thames the sugars and indigoes for which they have exchanged objects of their industry, and which have afforded them such resources.

"It is stated that about this time a caricature was exhibited in Paris in which the Emperor and the King of Rome were the most prominent characters. The Emperor was represented as sitting in the nursery with a cup of coffee before him, into which he was squeezing a beet-root. Near him was seated the King of Rome voraciously sucking the beet-root, while the nurse, standing near and steadfastly observing, is made to say to the youthful monarch, "*Suck*, dear, *suck ;* your father *says* it is sugar !"

"But as the doubt and ridicule here indicated gave way to a large extent in France before the development of the industry, that expressed in the English journals also gave place to an undercurrent of anxious inquiry as to the possible fate of the English colonial commerce, and the probable extent of the development of the new industries that were being so ardently fostered by Napoleon ; and it is related by the Prince Louis Napoleon that the English Government even made anonymous offers to Achard, first of the sum of $40,000, and later on of $100,000, if he would publish a work declaring that he had been carried away by his enthusiasm in his former publications, and that the results he then made public had by no means been confirmed by his later work. Failing in effecting in this way the result desired, it is said the Government induced Sir Humphrey Davy to write a brochure, in which he declared that, while sugar could be produced from the beet, the product was too bitter for consumption.

"But the impotency of these attacks upon the new industry is fully illustrated in its subsequent history. Napoleon, in his wisdom, continued his substantial encouragement of this and other agricultural and manufacturing industries in France by the appropriation of several millions of francs in their support at a time when the total revenue of his empire did not exceed 999,000,000 of francs (less than $200,000,000) and he was maintaining large armies in Spain and Portugal, and a very formidable navy on the high seas.

"But if the industry Napoleon had fostered and established fell with his downfall, its value had been demonstrated, and was even admitted in the first report of the Abbé de Montesquieu, minister of the interior under Louis XVIII, a report filled with the bitterest criticisms of the policy of the Imperial Government, accusing it of tyranny and imposition upon the rights of the people as concerns the manufacturing interests. In the course of this report the minister remarked that—

Mechanics and chemistry, enriched by a crowd of discoveries and ably applied to the arts, had caused rapid progress. The continental system, by forcing manufacturers to seek upon our own territory hitherto unknown resurces, brought about some useful results.

"The condition in which the wars left France and her industries at the beginning of 1815 necessitated the production of the revenue for the support of the government from external sources, for her fields and factories could not then bear a tax sufficient for the purpose. The customs duty this required maintained the prices of colonial staples at rates even higher than those which prevailed during the preceding reign, and operated as a substitute for the encouragement before given by the Government. It was on this account that the one factory, that of M. Crespel, at Arras, in the department of the North, which had survived the general wreck, was able in a year or two to yield to its enterprising owner and director a fair income with which to retrieve his broken fortune, and to again extend the industry in which it was shown he had such a deep interest. With the profits attained by one factory he established another until he finally became the proprietor of ten of the finest works of his time. His intelligence, industry, and enterprise gave an impetus to the culture and manufacture of the crop, and his example was soon followed by others in different parts of the country, and factories were established and worked with varying success. In 1823, Dubrunfaut published, in his work on the manufacture, information concerning the condition of the industry at that time, that he had been able to obtain on a tour among the principal factories of the day. From this work we gather the facts and figures tabulated below concerning the cost of culture of the beet and of the manufacture of sugar by some of the most progressive and successful manufacturers he had occasion to visit.

Name of grower.	Yield per acre in tons of 2,200 pounds.	Cost per ton of roots.
Mathieu de Dombasle	5.06	$5.80
Count Chaptal	12.45	3.68
Crespel	10.12	3.00
Cafler	12.145	2.66
Duke of Ragusa	10.12	3.36
General Preval	6.356	3.60
Masson	6.680	3.44
André	7.247	3.18
Grèvet-Pélé	10.777	2,50
Demars	15.222	4.00
Average	9.611	3.52

Name.	No. of days' work per annum.	Tons worked.	Yield in sugar.	Sugar per 100 of roots.	Cost.			Price paid for roots.
					Total.	Per ton of roots.	Per pound of sugar.	
			Pounds.				*Cents.*	*Per ton.*
Chaptal	120	600	....	3.0	....	....	11.8	$4.00
M. de Dombasle	150	2,250	99,000	2	$27,656	$12,29	27	6,05
Duke of Ragusa	120	1,000	82,500	3.75	87,000	8.70	9.9	4.00
Crespel	....	2,000	....	5	....	....	5.6	3.00
Cafler	150	1,000	....	....	....	....	6	....

"Dubrunfaut determines from his own observations as the cost of production 5.2 cents per pound avoirdupois for the intermittent process, and 4.8 cents for the continuous. Colonial sugars were at this time worth 1.40 to 1.50 francs per kilogram, or 12.7 to 13.6 cents per pound, and it was stated to be impossible to produce them at a cost of less than 5.5 cents per pound in the Antilles.

"The above estimate of cost given by Dubrunfaut was for working about 1,000 tons per annum. For working double that quantity the net cost appears at that time to have been greater, and reached 5.8 cents for the intermittent process and 5.4 for the continuous process.

"From this time the industry continued to spread rapidly, and to produce everywhere fruitful and profitable results, though, strange to say, no record seems to have been kept of the statistics of production in France until the year 1829, when it was stated at 4,000 tons.

"In Germany the industry did not revive until after 1835, when attention was called to it by Krause of Austria, and Schubarth of Prussia, who went to France, the first in 1834 and the second in 1836, to study the progress and condition of the manufacture. As a consequence of these trips and the prominence given by the press of the information they carried home with them, the culture of the beet was inaugurated anew, factories were again erected in large numbers, and the industry soon became so powerful as to be competent to contribute to the revenue of the Government.

HISTORY AND PROGRESS OF THE CULTURE OF THE SUGAR-BEET AND THE MANUFACTURE OF SUGAR THEREFROM IN THE UNITED STATES OF AMERICA.*

"Notwithstanding the progress that has been made in Europe in the culture of the sugar-beet and the manufacture of beet-root sugar, and immensity and value of the industry it has supplied to European nations, the knowledge and experience resulting has not been applied in such a way in the United States as to make the production of sugar from this source a matter of any commercial or industrial importance, although attempts at the introduction of the industry have not been wanting. In most cases the attempts, which have had varying success or rather failure, seem to have been originated and guided by enthusiasm rather than by sound judgment, based upon a previous close study of all the conditions which should influence or absolutely govern the success or failure of the enterprise. This is very evident from a review of the records we have of the various experiments which have been made both on a large and a small scale.

"The first experiment, made by two enterprising Philadelphians as early as 1830, was almost cotemporaneous with the final firm establishment of the industry in France and the great interest manifested in it there, but it seems that these gentlemen were wholly ignorant of the requirements either of the culture of the root or the extraction of sugar. and failure was the natural result of their efforts.

"Eight years later, David Lee Child, who had spent a year and a half in the beet-growing districts of Europe in careful study of all the requirements, both of culture and manufacture, undertook in a small way the production of beet-root sugar at Northampton, Mass. He was attracted by the method of drying the roots that had lately been invented by Schutzenbach, both for the purpose of preserving them and for facilitating the extraction of sugar, but being unable to obtain from Schutzenbach any information concerning the details of the method unless he would purchase the exclusive right to use in the United States, and give security for payment in case success should be obtained in a model factory, Mr. Child operated the method with apparatus of his own device, by means of which he was able, with a temperature of 150° to 185° Fahr., to dry 800 pounds in twenty-four hours. The dried product was ground, treated with three times its weight of water, and subjected to pressure, giving, it was said, a liquid twice as rich in sugar as the ordinary juice of the beet. In his little work entitled 'The Culture of the Beet and the Manufacture of Beet Sugar,' Mr. Child informs us that the cost of culture in the Connecticut River Valley was, in 1838 to 1839, $42 per acre, with an average yield of 13 to 15 tons; that the crop yielded 6 per cent. of sugar and 2½ per cent. of molasses, and the cost

* McMurtrie, *op. cit.*, p. 167.

of the sugar 11 cents per pound, pulp and manure not taken into account. But he does not mention the surface sown in beets nor the quantity worked up. From other sources, however, we learn that the quantity of sugar obtained was 1,300 pounds.

"The interest in the beet-sugar industry in the United States seems to have been quite dormant, or at least not sufficiently strong to manifest itself in active work, and its subsequent history, which, as before stated, was a rather checkered one, began in 1863 with the inauguration of the well-known enterprise at Chatsworth, Ill., by the Gennert Brothers, formerly of Braunschweig, Germany, and later of New York City, which, on account of the ill-chosen location as regards soil and climate, really the two principal conditions of successful culture, failed after a struggle of nearly six years. Bad management and lack of practical knowledge of the industry in the first few years, bad culture in 1868, deluging rains in 1869, and drought in 1870, in addition to the abundance of nitrates found to exist in the soils, appear to be the causes tending to the disastrous result. As a final struggle to maintain an existence the company removed the works to Freeport, in Stephenson County, of the same State, and though the saline character of the soil, which was a bane to the culture in the former locality, did not exist here, the efficient management of the able superintendent could not provide against the unfavorable climatic influences, and one year later the Germania Beet-Sugar Company finally succumbed, and its superintendent removed with some of the machinery of the late company to Black Hawk, Sauk County, Wis., to join with the co-operative enterprise that had been started there a year before. But the lessons of experience appear to have been no guide, for this attempt was made, like the previous ones, in a section not provided with the principal requirements for successful work.

"The crop of 1870 partially failed through drought. The machinery for the utilization of what there was arrived late, and the ponds upon which the company relied for water supply dried up before all the roots were worked for sugar, and a portion was left to be fed to cattle. Though additions were made to the works during the following year by means of machinery brought from Illinois and Fond du Lac, the result of 1871 does not seem to have been profitable, for since that time the enterprise has been so completely lost sight of that it is impossible to obtain any further information concerning it. The experiment at Fond du Lac, which, however, was not long continued, seems to have been the first to give unquestionably good results. It was started by two Germans, Messrs. Bonesteel and Otto, who organized a company with $12,000 capital, and though compelled, with their limited means, to work on a small scale, their success was such during the two years of existence of the enterprise as to attract the attention of capitalists on both sides of our continent, and they received an offer from Philadelphia of funds to carry on the work where they had so successfully established it, and another from San Francisco to put them in charge of the works of the Alvarado Sugar Company, which had just been organized with a capital of $250,000, and, finding the latter offer the most tempting, they abandoned their works at Fond du Lac and migrated to the Pacific coast, where they managed to carry on the work with varying success until 1873, when it was reported that the company proposed removing to a more eligible locality. But it does not appear that this proposition was carried out, for what reason we are not informed; though Mr. Otto, who was then superintendent, and who, with his colleague in the Fond du Lac enterprise, Mr. Bonesteel, had become partners in this company, was shortly afterwards transferred to Soquel, in Santa Cruz County, where as late as 1876 the factory was reported as being in successful operation. The Alvarado Company struggled on until 1876, when drought having destroyed the crop so completely that there was no raw material for work in the factory in the ensuing winter, the company not having realized enough to enable them to carry over until the following season, failed financially, and permanently closed their operations.

"The Sacramento Valley Company was organized in 1869, and commenced extended operations in manufacture in 1870, and its existence was maintained until the close of 1875, when the machinery, which had cost $160,000 in Germany, was offered for sale at $45,000, and we have no information to the effect that it has been sold. Concerning the industry, a writer in the Alta California, during 1869, says:

"'Something new and unexpected has revealed itself. In Europe the beet attains its maximum of sugar in the latest period of growth before the frost sets in. Here it has lost half its sugar in the last six weeks—last of October. The beets taken from the same soil and milled in December by Wadsworth, superintendent, had the full complement of sugar.'

"The Soquel factory soon followed the fate of the others, but causes of its failure have not been assigned.

"The importance the manufacture attained in California is shown in the following statistics of beet sugar produced, published in 1874 by the State Agricultural Society:

	Pounds.
1870	500,000
1871	800,000
1872	1.125,000
1873	1,500,000

"But notwithstanding these figures, which are certainly flattering to the industry, there has not been a factory in operation in the State since 1876, and the capital invested in the manufacture, nearly $1,000,000, has been a total loss, the causes of which may undoubtedly be traced to conditions determined in the Department during the present year by the study of European history and practices to be manifestly unfavorable and decidedly deleterious to the successful prosecution of the industry. We refer more particularly to the meteorological conditions prevailing during the season of growth, which, as appears from the relations worked out, have a clearly defined influence for good or for evil, for success or failure, in the culture of the sugar-beat, and it is an interesting fact to note that at none of the localities where the experiments made have been attended with failure are the prevailing meteorological conditions found within the limits determined to be favorable to or governing the extension of successful culture.

"The experiments made up to this time received no aid or encouragement either from the State governments or from the General Government, with the exception of the provision that no machinery purchased abroad and imported for manufacture of sugar from the beets in this country should be subject to customs duty, and the limited assistance given by the Department of Agriculture in contributions of seed of the better varieties for experiment, and such information on the subject of the culture of the root and the manufacture of sugar as could be obtained by the means at hand; but this limited assistance was not of a character to produce any very marked effects.

"In 1870 to 1871 the States of New Jersey and Massachusetts made legislative provision exempting from taxation for ten years from date all capital and property engaged in the beet-sugar industry, but no practical results seem to have followed this provision. In New Jersey, however, Mr. Joseph Wharton, of Camden, has during the past three years devoted a portion of his estate at Batsto to some very intelligent experiments in the culture, which, as regards the quantity of the product, has given unsatisfactory results, and only tend to show that the climatic conditions of the section, possibly combined with the light character of the soil, are not such as to render the permanent establishment of the industry in that locality possible.

"In 1876 the Canadian Government offered a premium of 1 cent per pound for all sugar manufactured from the beet-root, the total sum paid to any one individual company or corporation not to exceed, however, $7,000 per annum.

"This premium stimulated the culture of the crop and the establishment of factories, which have continued in active and profitable operation.

"The State of Maine followed the worthy example of its near neighbor and in the same substantial terms; the Forest City Sugar Refinery at Portland hastened to take advantage of the premium offered, and the experiment on a small scale in the manufacture by the company, as had been the culture by the farmers in 1878, resulted in such brilliant success that the company have this year so enlarged the capacity of their works as to enable them to work 150 tons of roots per day and have secured from the farmers a crop from 1,250 acres of land. Their success has also animated the people of Massachusetts, who have organized a company for work at the locality of Child's experiment of 1838–'39, at Northampton, Mass.

"In 1876 and 1877 Delaware appropriated $300, and in 1878-'79 $1,500 to be expended in premiums, etc., to stimulate the culture, and the result has been the establishment of the Delaware Beet Sugar Company at Wilmington.

"In California also interest in the industry has again been awakened through the instrumentality of Mr. Th. Gennert, whose worthy enthusiasm led to the establishment of the enterprise in Canada and in Maine. The work is to be renewed at the factory of the former Alvarado Company, and Gennert's scheme for drying the beets for preservation and transportation, which was attended with such disastrous results at Chatsworth and in Maine, is to be tried once more. It is understood that Mr. Gennert is now interested in the Alvarado Company and expects to carry out his plan for drying the beet-roots, and, thus diminishing the cost of transportation, increase the profits of manufacture, in which we hope he may be successful. The culture of the beet has also been undertaken in Santa Clara County, where it is proposed to supply deficient moisture by irrigation, and to dry in open sunlight the roots, of which it is declared two crops can be produced in one year. Without wishing to discourage the enterprise in any way, we may venture to express the hope that the promoters are acquainted with the experience of the growers of the south of France and Italy, as described by Gustave Heuzé in his work '*Les Plantes Fourragères*,' page 9, where he says:

"'The beet succeeds well in the cold climates of Europe. It will grow in southern countries, but it suffers there from heat or drought; its root remain small, green, and contains little sugar. An attempt was made to hasten its growth in Lombardy by frequent irrigation during the summer, but irrigation was fatal to it, and growers were forced to adopt other means to assure success.'

"We would also call attention to the fact that in Algeria, where the enterprise of preparing beets for preservation and transportation by drying in open sunlight, the success, if any was obtained, has not appeared worthy of record.

"Besides the arrangements that have been made for the production of sugar from the beet at the different places mentioned active interest has been awakened elsewhere, particularly at Baltimore, Md., Chester, Pa., and at various localities in New York, but these movements have not yet assumed definite shape."

THE EARLY HISTORY OF BEET-SUGAR INDUSTRY AT ALVARADO.*

"No history of Alameda County would be complete without some mention of the rise and progress of this promising industry, which, so far as California and the Pacific coast are concerned, had its origin at Alvarado—its failure and its final success.

"The first attempt to manufacture beet-root sugar in California was made at Alvarado in 1869. Messrs. Bonesteel, Otto & Co., who were engaged in a small way in the business at Fond du Lac, Wis., opened

* Bull. No. 5, Chem. Div. U. S. Department of Agriculture, p. 89.

a correspondence upon the subject with General C. I. Hutchinson, E. H. Dyer, and others on this coast. The matter was pushed with zeal, and the 'California Beet Sugar Company' was organized with a capital stock of $250,000. The stockholders were: General C. I. Hutchinson, Flint, Bixby & Co., T. G. Phelps, E. H. Dyer, E. R. Carpentier, E. Dyer, W. B. Carr, W. T. Garratt, and E. G. Rollins, all well-known capitalists and enterprising business men of California; and A. D. Bonesteel, A. Otto, and Ewald Klinean, of Wisconsin. The eastern parties, who were to assume the technical management of the business, arrived in California in the spring of 1870, and arrangements were immediately made for the erection of a factory. The location chosen was the farm of E. H. Dyer, at Alvarado. The work was pushed with such energy that the building was completed by the contractor, B. F. Ingalls, esq., in November of the same year.

"It is unnecessary to follow minutely the history of this company. It is sufficient to say that, after running four years at Alvarado, through the incompetency of the technical managers, it proved a financial failure. Messrs. Bonesteel & Otto contended that the location at Alvarado, not being a suitable place for the business, was the cause of the failure, and succeeded, by their plausible representations, in organizing a new company, which purchased the Alvarado machinery and removed it to Soquel, Santa Cruz County, where, after operating a few years, subjecting its stockholders to a heavy annual loss, the enterprise was abandoned.

"E. H. Dyer, who had bought the buildings and a portion of the land owned by the old company at Alvarado, still had faith in the business, believing that with good management it could be made to pay at that place. He found it very difficult, however, in the face of so many failures, to induce capitalists to invest a sufficient amount to give the business another trial, and it was not until 1879 that the Standard Sugar Manufacturing Company was incorporated. The company consisted of A. E. Davis, O. F. Giffin, E. H. Dyer, Prescott, Scott & Co., J. P. Dyer, and Robert N. Graves, with a capital of $100,000. It was soon ascertained that more capital was needed, and the company re-incorporated under the name of the Standard Sugar Refinery, with a capital stock of $200,000. The officers are: O. F. Giffin, president; J. P. Dyer, vice-president; E. H. Dyer, general superintendent; W. F. Ingalls, secretary; trustees, O. F. Giffin, R. N. Graves, J. P. Dyer, G. H. Waggoner, and E. H. Dyer. This company has made a success of the business from the start. It earned 33 per cent. on the capital invested the last or third campaign, and is now just commencing on its fourth campaign with very flattering prospects. The success of this important home industry is greatly due to the general management of Mr. Dyer, who owns one-fourth of the stock, and who, profiting by former experience, is able to avoid many mistakes which have caused the failures of other establishments of the kind. The present factory has been enlarged and improved until it now has a capacity of about 100 tons per day; employs at the factory 125 men, to say nothing of the great amount of labor necessary to produce the beets, harvest and haul them to the factory. One, to obtain an adequate idea of the business of this company and the great good it is doing in the way of using the products of the farmers and keeping employed so many of our people, should see the works in operation during the months of September, October, and November, when beets are being received.

"There are frequently lines of teams, all heavily laden with beets, from a quarter to sometimes half a mile in length, pushing along in line to reach the company's scales and deliver their loads. It is a scene of great activity. From fifteen to twenty thousand tons of beets are used each campaign, which require for their production ten to fifteen hundred acres of land. The company disburses among its workmen and the farmers nearly $150,000 a year for labor and material used; all produced in Alameda County. They have turned out each campaign one and a half million pounds of pure white sugar. No low grades or yellow sugars are put on the market by them."

BEET-SUGAR FACTORIES AT CHATSWORTH AND OTHER PLACES.

In regard to these factories Prof. W. A. Henry writes as follows*: "The history of attempts to manufacture sugar from the beet in America is one of almost continuous failure. In 1838 David Lee Child manufactured sugar in Massachusetts at 13 cents per pound, but a small quantity being made. In 1863 the Gennert Brothers, from Germany, built a factory at Chatsworth, Ill., in what is said to have been an unfortunate location, as the soil there was not suitable for beet-growing. Bad culture, wet seasons, drought and a soil too full of mineral matter brought disaster, and about 1870 the enterprise collapsed. From Chatsworth the machinery was moved to Freeport, where the Germania Sugar Company after a brief existence dissolved, and the machinery was again moved, this time to Black Hawk, Sauk County, Wis., where failure was again met. At Fond du Lac, in this State, Messrs. Bonesteel & Otto organized a company with $12,000 capital, and struggled during two years, making, it is reported, considerable sugar. Their success could not have been very marked, for they accepted an offer to join a company at Alvarado, Cal., which started out with $250,000 capital. The Alvarado Company also went to the wall, as did two or three other California concerns. A factory was also started in Maine, and another in Delaware, but these met the universal fate. The Alvarado factory was reorganized, and for several years made considerable quantities of sugar, the product some years reaching two or three million pounds; but owing to the antiquated machinery and limited capacity the investors received little or no dividends.

* Western Farmer, Madison, Wis., March 29, 1890.

"The beet-sugar industry in America may be said to have closed its first era a couple of years ago, and the results, from a financial standpoint, may be summed up in one phrase, 'complete failure.'

"We are now, I trust, entering the second era, which will doubtless be more successful than the first, but its history lies in the future, and its making is with the people.

"The second era of the industry may be said to have begun with the reorganization of the Alvarado factory upon a sound basis last year, and the building of the Spreckels' factory at Watsonville, Cal. These enterprises are in the hands of men who will succeed if success is possible."

For further particulars respecting the Chatsworth factory I wrote to Mr. John P. Reynolds, of Chicago, and received the following reply:

CHICAGO, *December* 9, 1889.

DEAR SIR: Your favor of 5th instant, requesting written papers or observations I may wish to make upon the subject of beet-sugar manufacture in this country, is received.

Twenty-odd years ago, at Chatsworth, Ill., some few of us made about a $300,000 failure in attempting to establish that manufacture. The factory was well equipped, as we understood it. The lands, say 1,000 acres, were first-class high, rolling prairie. Compared with the present the processes of manufacture and machinery were doubtless imperfect, but they were supposed to be the best approved in Germany at that time. After we gave it up the business was carried to Freeport, Ill., and started up by three gentlemen of large wealth, on good old lands, by the side of a town of 15,000 people. It failed again.

Without going into details further, I must say that I have given up hope for the early success of beet-sugar industry in this country, because I believe the essential conditions are not to be found here at present. These conditions relate to the production of the beets. The manufacturer must grow his own beets, or have them grown in the vicinity by others. He can not command the necessary labor to grow them himself, except at a cost that the results will not justify. There is no crop within the whole range of agriculture more difficult to produce than a crop of beets suitable for the manufacture of sugar. An army of women and children (being the cheapest labor) is required imperatively at special times, and I know of no community where this army can certainly be had when needed and at a fair cost.

If others grow the beets, contracts must be made in advance for the entire crop of each, a certain number of acres to be cultivated. The product per acre is variable and uncertain in both quantity and quality. There may be a superabundance for the capacity of the factory, or there may be a failure of the crop almost entirely. As to price per ton the advantage is always on the side of the farmer. The manufacturer must pay what the farmer may demand, or quit the business and lose his plant. The farmer can use his land for other crops; the factory will make only beet-sugar.

With irrigated lands and slave labor, or its equivalent, I can understand that sugar from beets can be produced profitably in this country. I would like to believe this industry will soon demonstrate the error of my present convictions thus briefly stated, and certainly the effort to make it successful is worthy any man's ambition.

Yours, truly,

JOHN P. REYNOLDS.

Mr. H. W. WILEY,

Chemist, Department of Agriculture, Washington, D. C.

STATISTICAL.

THE GERMAN CAMPAIGN OF 1888–'89.

During this campaign the new law levying a part of the tax on the beets and a part on the sugar produced came into operation for the first time. The object of this law is to diminish the bounty paid on exports. By the new law the tax on the beets has been reduced to .80 marks per 100 kilograms, instead of 1.7 marks as by the former law. On the other hand, sugars entering consumption pay 12 marks per 100 kilograms, whereas before they paid nothing when made from native beets.

The quality of the beet root harvested in 1888–'89 was much inferior to that of the preceding year. This inferiority was caused by a late wet spring and an excess of rain in June and July. While the yield of beets was larger, the saccharine strength was lower than had been known before in many years. The yield of sugar was also diminished by early frosts, by which many beets were frozen before they could be properly harvested and siloed. The juice of such beets was cooked with extreme difficulty, being difficult to filter and granulate. Many factories by reason of these difficulties were led to refuse to accept beets that had been frozen.

The following table, according to M. Licht, gives the actual production of sugar in Germany in metric quintals* and the percentage of yield on the weight of the beet from 1871 to 1889:

[Sugar, April, 1890, p. 496.]

Year.	Real production.	Actual yield.	Year.	Real production.	Actual yield.
		Per ct.			*Per ct.*
1871–'72	1, 864, 419	8. 28	1880–'81	5, 730, 214	9. 06
1872–'73	2, 625, 511	8. 25	1881–'82	6, 222, 885	9. 92
1873–'74	2, 910, 407	8. 25	1882–'83	8, 489, 226	9. 71
1874–'75	2, 564, 124	9. 30	1883–'84	9, 606, 093	10. 77
1875–'76	3, 580, 482	8. 60	1884–'85	11, 467, 303	11. 02
1876–'77	2, 909, 227	8. 19	1885–'86	8, 381, 049	11. 85
1877–'78	3, 805, 091	9. 30	1886–'87	10, 237, 339	12. 32
1878–'79	4, 301, 551	9. 35	1887–'88	9, 591, 184	13. 77
1879–'80	4, 154, 152	8. 64	1888–'89	9, 904, 776	12. 55

* Divide by 10 to get tons of 2,200 pounds each.

COMPARATIVE DEVELOPMENT OF THE CANE AND BEET SUGAR INDUSTRY.*

The following table expresses in tons of 2,200 pounds the relative amounts of cane and beet sugar made in the world during the past seven years:

Year.	Beet.	Cane.	Total.
1883–'84	2, 361, 000	2, 323, 000	2, 684, 000
1884–'85	2, 546, 000	2, 351, 000	4, 897, 000
1885–'86	2, 220, 000	2, 340, 000	4, 560, 000
1886–'87	2, 730, 000	2, 345, 000	5, 075, 000
1887–'88	2, 452, 000	2, 470, 000	4, 922, 000
1888–'89	2, 765, 000	2, 280, 000	5, 045, 000
1889–'90	3, 500, 000	2, 278, 000	5, 778, 000

It is seen from the above table that the production of cane-sugar has remained stationary or even diminished during the last septennial period while the production of beet-sugar has experienced an enormous progress.

Willet and Gray (Louisiana Planter and Sugar Manufacturer, April 5, 1890), give the following estimate of the total sugar crop of the world, in tons, for the last five years:

Country.	1889–'90.	1888–'89.	1887–'88.	1886–'87.	1885–'86.
Cuba	600, 000	530, 000	610, 000	608, 900	705, 400
Porto Rico	70, 000	55, 000	50, 000	86, 000	64. 000
Trinidad	60, 000	60, 000	60, 000	69, 000	49, 200
Barbadoes	60, 000	50, 000	60, 000	65, 000	44, 000
Jamaica	30, 000	28, 000	30, 000	21, 000	17, 000
Antigua and St. Kitt's	28, 000	25, 000	26, 000	25, 000	25, 000
Martinique	40, 000	38, 000	39, 000	41, 000	33, 000
Guadeloupe	50, 000	45, 000	50, 000	55, 000	37, 000
Demerara	125, 000	108, 000	110, 000	135, 000	111, 800
Reunion	30, 000	25, 000	32, 000	32, 000	35, 000
Mauritius	125, 000	132, 000	120, 000	101, 800	114, 200
Java	310, 000	364, 000	396, 000	363, 950	365, 950
British India	60, 000	60, 000	55, 000	50, 000	50, 000
Brazil	150, 000	220, 000	320, 000	260, 000	186, 000
Manila, Cebu, and Iloilo	180, 000	210, 000	174, 000	180, 000	186, 000
Louisiana	125, 000	145, 000	158, 000	80, 900	127, 900
Peru	30, 000	30, 000	30, 000	26, 000	27, 000
Egypt	35, 000	35, 000	35, 000	50, 000	65, 000
Sandwich Islands	120, 000	120, 000	100, 000	95, 000	96, 500
Total of cane	2, 228, 000	2, 254, 000	2, 465, 000	2, 345, 550	2, 339, 950
Total of beet	3, 550, 000	2, 753, 844	2, 451, 950	2, 730, 206	2, 219, 973
Cane and beet	5, 778, 000	5, 007, 844	4, 916, 950	5, 075, 756	4, 559, 923

La Sucrerie Belge of March 15, 1890, page 372, gives the following estimate of the total production of beet sugar in Europe during the past four years, in tons of 2,200 pounds:

Country.	1889–'90.	1888–'89.	1887–'88.	1886–'87.
Germany	1, 220, 000	978, 000	953, 400	1, 015, 600
Austria	730, 000	514, 000	400, 000	550, 000
France	750, 000	460, 000	420, 000	497, 000
Russia	445, 000	503, 000	430, 000	455, 000
Belgium	172, 000	96, 000	93, 000	91, 000
Holland	55, 000	35, 000	37, 000	36, 000
Denmark	20, 000	19, 000	21, 000	18, 300
Other countries	25, 000	21, 000	14, 000	13, 000
Total	3, 417, 000	2, 626, 000	2, 368, 400	2, 675, 900

* La Sucrerie Indigene, March 11, 1890, p. 233.

STATISTICS OF THE PRODUCTION OF CANE AND BEET SUGAR.

Licht, of Magdeburg, in his last report (Journal des Fabricants de Sucre, March 26, 1890), gives the following figures for the production of beet sugar in Europe for the last three campaigns:

[In tons of 2,200 pounds.]

Country.	1887–'88.	1888–'89.	1889–'90.
Germany	956, 166	990, 604	1, 260, 000
Austria	428, 616	524, 242	750, 000
France	392, 821	466, 767	775, 000
Russia	441, 342	525, 387	475, 000
Belgium	140, 742	145, 804	200, 000
Holland	39, 280	46, 040	60, 000
Other countries	79, 980	87, 000	80, 000
Total	2, 481, 950	2, 785, 844	3, 600, 000

PRODUCTION IN RUSSIA.*

During the campaign of 1889–'90 two hundred and twenty-five factories were operated in Russia. The harvest of beets amounted to 17,370 kilograms per hectare against 18,680 kilograms per hectare the preceding year. The beets also were much poorer in quality during the last year, the mean polarization being 12.93 per cent. of sugar against 14.20 per cent. the preceding year.

THE PRODUCTION OF CANE SUGAR IN JAVA.*

During the season of 1889 there were operated in Java one hundred and seventy-eight factories, producing 5,440,397 piculs of sugar.

PRODUCTION OF SEED.

There is, perhaps, no other agricultural crop which has illustrated in so marked a manner the importance of seed selection as the sugar beet. By the careful selection of those variations in the original beet which seemed most favorable to the production of sugar, and the careful selection of beets in the production of seed during the succeeding year, and by judicious and scientific fertilizing for the purpose of increasing the sugar content, there has been a great evolution in the sugar-producing power of the beet which has placed it at the head of the sugar-producing plants of the world.

The influence of the quality of the seed, according to Vilmorin, is absolutely predominant from the point of view of the results obtained in the culture of the sugar beet. The numerous experiments of scientific investigators has shown that remark to be true. In France the firm of Vilmorin-Andrieux & Co. has paid special attention to the improvement

* Journal des Fabricants de Sucre, March 19, 1890.

of the standard varieties of the sugar beet by the method above mentioned. They have endeavored to produce different varieties of beets of which each one would have all the possible advantages in the different economical and culture experiments to which manufacturers and farmers will submit them.

It is true, without doubt, that the same variety of beet could not be the most advantageous in every case, and that, according to the results to be obtained, it might be an advantage in one place to cultivate a variety extremely rich and in another place one, which, while still rich in sugar, would also produce a heavy yield in pounds. To these different needs different varieties of beets respond. In one case the pure white variety, in another the white variety with green neck or the rose variety with rose neck, or the Vilmorin Improved, a variety which is suitable everywhere and particularly in those countries where the duty on beet-sugar is laid directly on the beet. Since the introduction of the new law in France, in 1884, levying the tax upon the actual weight of beet produced, the White Improved Vilmorin beet has recommended itself by its exceptional richness, its great purity, and the ease with which it can be preserved. But in order to meet all the conditions necessary to the greatest success it is necessary to find out by experiment that variety of beet, which, in any given locality, fulfills most of the conditions required to produce a high yield of sugar with a minimum cost and one which will be equally profitable to the farmer and manufacturer.

At the present time, it is necessary in this country to go abroad for beet seed of the highest character. Up to the present time the sugar-beet seed which has been grown in this country has been produced without especial reference to the conditions necessary to maintain the beet at a high standard and to improve it as is done in foreign countries. In other words, the sugar-beet seed which one will obtain from American dealers, if it should be that which is grown at home, does not come with the pedigree of the beet, in regard to content of sugar and purity of juice, nor with that assurance of care in cultivation which the professional producers of beet seed in foreign countries bestow upon their work. There is no reason, however, to suppose that it is impracticable to produce beet seed in this country of as high a grade and of as pure a quality as that which can be obtained in other countries. The method of doing this will be briefly indicated.

In growing the beets the greatest care should be taken to secure all the conditions necessary to produce a beet of maximum richness in sugar, coupled with a yield per acre of fair proportions. This can be done by attending to the directions for culture to be given, combined with judicious application of those fertilizers which will tend to increase the sugar content of the beet without unduly increasing its size. The fertilizers which are most suitable for this purpose are carbonate of lime, when it is not present in sufficient quantities in the soil, a small quantity of magnesia, and larger quantities of phosphoric acid with varying proportions of potash and nitrogen, according to the character of the soil in which the beets are grown. No certain rule can be given for the application of fertilizers until the conditions of the season and the character of the soil in each particular locality have been carefully studied experimentally. For this reason, it is certain that in this country, as in others, the business of producing beet seed will be one entirely distinct from that of raising beets for manufacture or for the manufacturing thereof. It is this business which will require not only the highest scientific agriculture but the most careful agronomic skill.

SELECTION OF "MOTHERS."

The beets which are to be used for producing the seed should be selected on account of the possession of those properties which are most suitable to secure the highest results in the production of sugar. In the first place, all beets of irregular or unwieldly shape should be rejected; those selected should be of uniformly even texture, smooth outline, and symmetrical shape.

The sugar content of these beets should be determined by the analysis of others grown in the same plot and of the same seed, and thus obtain the average content of sugar for the whole lot. Only that class of beets showing the highest content of sugar combined with the qualities given above, and the greatest purity of juice, should be preserved. In many cases the beets themselves, which are to be used for propagation of seed, are subjected to analysis by the removal of a cylindrical section by an instrument provided for that purpose and the analysis of this section. In this way the actual sugar content of the beet which produces the seed can be obtained. It is said that good results have also been secured by replacing the portion of the beet removed by sugar at the time of planting, which will afford an additional food product for the earlier growth of the beet in its second year.

Another method of selecting the beets, which has been widely employed, is that of determining their density. A solution of some substance is made in water, such as salt or sugar, of such a density as to permit beets of inferior quality to float on the surface and those of superior quality to sink. These heavier beets, other things being equal, contain larger quantities of sugar and are more suitable for the production of seed. The beets, of course, which are to be used for the production of seed must be very carefully harvested so as not to be bruised, leaving the roots as much as possible uninjured, and they must be carefully preserved in silos over the winter until the time for transplanting in the spring. The transplanting and the successful cultivation of the beets need no detailed description.

The character of the beet is also sometimes determined by removing a small portion, as indicated above, for polarization, expressing the juice and determining its specific gravity by weighing in the juice a silver button of known weight.

The absolute necessity of securing a few beets of the highest sugar co-efficient and purity for the purpose of producing a crop of seed in third, fourth, or fifth year, according to the number selected, has in the last few years been recognized to a degree unknown before. At first it was the custom to select the beets, by some of the methods mentioned above, in large numbers sufficient to grow in the second year seed for the market. A much more rational method, however, and one which secures higher results, consists in a more careful selection of the mother beets for the purpose, not of producing seed for the market in the second year, but only for the purpose of producing for securing an additional crop of beets in the third year which in the fourth year will produce seed for the market. The methods employed by different seedsmen vary somewhat, but the principle in all cases is the same. The general method may be indicated by that pursued by Dippe in Quedlinburg :*

First year.—Seed planting for mother beets, from seed which came from the highest polarizing beets of different varieties, which have, of course, been kept separate. The planting is in rows 18 inches apart, and the plants are cut away in the rows so as to stand 10 or 12 inches apart. At the time of harvesting the beets are selected out according to form, growth, and leaf formation, as these best approximate the characteristics of the parent variety.

Second year.—In March and April these selected beets are examined in the laboratory† in the following manner :

At a certain point which it is presumed will give an average of the entire beet, a cylindrical piece is cut out, subjected to strong pressure in a juice-press, which will give, for example, from 17 grams of beet 10 grams of juice, of which 5 cubic centimeters are diluted with lead acetate and water to 25 cubic centimeters, filtered and polarized. For the different varieties minimum limits are established, and the beets are arranged in three classes according to their polarization :

First, beets which go below the limit and are thrown out; second, beets which are above the limit, and fairly good tor seed purposes, and, third, beets which show an extra high figure.

These extra good beets are now examined still further, two more cylinders taken out, and the sugar estimated by the extraction method. From this result and the estimation of the sugar in the juice the (apparent) content of juice is calculated. Those beets which do not reach a standard, established for each variety (between 92 and 94), are thrown out, while those that attain it are the chosen "mother beets" of the crop, which are to perpetuate the variety, and which furnish the seed for each new succession, as mentioned in the first paragraph.

In this second year are planted out all the beets saved, the extra and medium as well; the former furnish seed for extra mother beets, which

* Stammer, pp. 200, *et seq.*, Lehrbuch der Zucker Fabrication.

† This is not done until spring in order that only well-preserved beets may be chosen.

are used as indicated for the normal-sized mother beets which furnish seed for a new succession, while the latter are to produce a generation of dwarfs, the seed from both being harvested this year.

Third year.—The seed from the medium and extra mother beets is planted, and the latter produce the mother beets for future breeding purposes, as indicated, but the plants from the former seed, which was planted a little later than would be the case for beets ordinarily, and in soil fertilized with ammoniacal superphosphate and also some guano, in rows 12 inches apart, are cut out to about every 3 to 5 inches. The small beets are very carefully preserved under a thick covering of earth. In the spring of the

Fourth year.—They are uncovered and planted at about 26 to 24 inches apart. The seed from these when harvested in the fall is ready for the market, so that it has taken five years to attain this end.

In the establishment of Branne, in Biendorf, the procedure is similar, but the beets are selected by their specific gravity in the field. A woman sits at a table and cuts from each beet a very small piece and throws it into a solution of salt of known density (for example, with the Klein Wanzleben, 16° Brix). If the piece of beet floats, the corresponding beet is thrown away, but if it sinks the beet is reserved for further investigation in the laboratory. The beets chosen in this way are submitted to further selection by the examination of the juice from a cylinder.

In a somewhat different way, but still by means of the examination of individual beets, is the culture of the Klein Wanzleben variety carried on by Rabbethge, in Klein Wanzleben, whose object is not so much to furnish establishments with all the seed they require for planting, but rather with seed for the production of mother beets, and their own seed from these. The fact that Klein Wanzleben has never yet harvested more than 3 tons of seed in a season indicates the character of the work, which is much to be commended.

The seeds are always taken from mother beets of considerable weight, never from small or dwarf beets, and the aim is not so much to produce individual beets of exceptionally high sugar content, but large beets as well; that is, beets which give the highest yield of sugar from a given amount of land. These roots, which are chosen from a field of the best (Elite) beets, and which possess most distinctly the characteristics of the variety, are weighed and their juice polarized, and this operation is continued until 20,000 beets are chosen which fulfill the requirements as to weight and sugar content.

These 20,000 best mother beets are sufficient to furnish the planting of a hectare (2½ acres), and from them are obtained 40 to 60 hundred weight of the best (Elite) seed, and this gives the following year 60 to 100 hectares of the best (Elite) beets, or 5,000,000 to 7,000,000 plants. From these are finally chosen the 1,500,000 seed-bearers which furnish the planting of 100 hectares and the seed for sale and for the perpetuation of the breed.

An entirely different method of selection is what is known as "family" breeding. Hundreds of specially-selected beets, excellent in every way, are planted out separately. The seed of each is gathered and planted separately. If among the beets thus obtained any are found that excel the mother beet in every respect, and this improvement endures through several generations, these are incorporated with the other mother beets and used for breeding. As examples of weight and polarization of the selected beets the following figures for the highest and lowest weights are given, representing the best mother beets of the years 1883 and 1884:

Weight.	Sucrose in juice.	Weight.	Sucrose in juice.
Grams.	*Per cent.*	*Grams.*	*Per cent.*
1,550	11.24	600	15.11
1,450	13.68	600	16.28
1,250	14.29	600	16.28
1.500	15.87	400	16.13
1,450	14.60	550	15.62
1,700	11.76	400	16.83
1,860	14.86	550	16.88
2,100	14.35	400	16.63
1,900	14.60	600	15.63
600	16.13		

Among 200 beets were found only 11 with a weight of less than 500 grams; 12 with a weight of 500 to 600 grams; 29 with a weight of 600 to 700 grams; 21 with a weight of 700 to 800 grams; and finally 127, or 63 per cent., with a weight of over 800 and up to as high as 2,100 grams.

The beets between 700 and 1,000 grams are of nearly identical sugar content, a peculiarity of the Klein Wanzleben variety.

The established normal weight varies, according to the season, between 600 and 900 grams; in the year 1883 it was 897 grams, corresponding to the average of the beets from a field.

A still different method is followed by v. Proskowetz (Kwassiz). The beets from which selections are to be made are placed in a solution of salt showing 17.5° Brix, and those which float are used as fodder; those which sink are analyzed for sugar content by the alcohol extraction method, for which purpose a small quantity, half the normal weight, is cut out with a rasp and polarized in a 400-millimeter tube. Beets which give at least 19 per cent. of the beet in sucrose form the first class; those showing 18 to 18.9, inclusive, the second, and those from 16 to 18 the third. Beets under 16 per cent. are used for fodder.

PRESERVATION OF BEET-SEED.

It is recommended by D'Haussy (Jour. des Fabricants de Sucre, April 16, 1890) to place in each bag 100 pounds of seed, 1 pound of powdered sulphur, and 1 ounce of carbolic acid, and mix thoroughly.

These substances preserve the seed completely from every kind of insect from the time it is planted until the root is developed. The outside of the bag should be coated with tar, and the seed kept therein for two weeks before planting.

VARIETIES OF BEETS GROWN IN FRANCE.*

THEIR CHARACTERS, MODE OF SELECTING, ETC.

"The importance of the variety or race of the beet to be grown for sugar can not be questioned. A beet giving a large cultural yield rich in sugar involves no more cost to the grower in its production than one giving a small yield and low saccharine value. It is therefore useful to choose those which will give the greatest returns and be at the same time the most satisfactory in every way to the grower who must produce them and to the manufacturer who must extract the sugar.

"For the latter it is admitted that the raw material—the juice of which contains the smallest percentage of mineral and organic impurities, other things being equal—will give a larger yield of sugar than juices in which these constituents exist in larger proportions, and it is well known and generally understood that these favorable conditions are found in roots of moderate size more frequently than in large ones. Thus Briem† says 'The size of the beet is in the inverse ratio of its content of sugar and salts; the content of water increases with the size and weight of the beet'; and Champion and Pellet state‡ that beets of good quality generally have an average weight of 700 to 800 grams (1½ to 1¾ pounds), and this size seems to be generally adopted as the most favorable by the best authorities on beet culture in France and by the manufacturers almost unanimously.

"The rule that the smaller the beet the richer in sugar appears to find illustration if not complete confirmation in the results of examination of the beets submitted by Professor Deherain § to experiment at the college farm at Grignon and produced from seed furnished by Vilmorin-Andrieux & Co.

Number.	Improved exposition beets.		Improved beets No. 848.		Pink-top beets, Verrières.		Pink top No. 34.	
	Weight of beet.	Sugar in juice.	Weight.	Sugar in juice.	Weight.	Sugar in juice.	Weight.	Sugar in juice.
	Grams.	*Per cent.*	*Grams.*	*Per cent.*	*Grams.*	*Per cent.*	*Grams.*	*Per cent.*
1	395	18.1	282	20.0	980	13.10	530	13.75
2	365	16.7	330	20.0	460	12.05	622	13.10
3	720	16.4	660	18.8	630	11.30	837	12.50
4	600	15.6	450	18.7	627	10.00	1,115	11.25
5	620	15.0	385	18.4	890	9.84	1,040	10.60
6	740	13.9	335	18.4	1,150	9.20		
7	1,130	13.4	560	17.7				
8	850	13.2	580	16.9				
Averages	677	15.5	447	18.6	789	10.91	828	12.24

"The form of the beet seems also to be an important feature in the consideration of the proportion of sugar to be obtained, and Champion

* McMurtrie, *op. cit.* pp. 71 *et. seq.*

† Journal des Fabricants de Sucre, October 23, 1878.

‡ La Betterave à Sucre, p. 98.

§ Annales Agronomiques.

and Pellet further state,* concerning beets of good quality, "their form is elongated and tapering." This admits of more thorough penetration of the root in the soil, more complete contact with the nutritive elements, moisture, etc., insures the plant against variations of existing conditions, and consequently a healthier state, from which must naturally follow a better quality.

"Corenwinder and Contamine † find that there is a relation between the size of the leaves and the richness of the roots; that roots which bear leaves of broad surface are generally more rich in sugar than those having small leaves upon a contracted top, and these facts are confirmed by analyses of subjects taken from the same field. At the same time Deherain concludes from his researches ‡ that the weight of leaves of small beets is relatively greater than is produced by larger ones. The relations found are as follows:

Variety of beets.	Weight of leaves.	Weight of roots.	Sugar in 100 of juice.
	Grams.	*Grams.*	
Pink top O	281	1,393	9.94
Pink top Enterré	375	984	10.18
Improved 1,093	531	863	14.42
Improved 927	531	787	14.78

In connection with this relation between the size and richness of the sugar-beet and the number and weight of leaves they bear Champion and Pellet § give following figures.

Variety of beets.	Leaves per 100 of roots.	Sugar in beet.
	Pounds.	*Per cent.*
Improved Vilmorin	56	14.5
Simon Legrand (choice)	33	13.3
Ordinary of sugar factories	20	11.8

Beets produced in special cultures.

Variety.	Roots.	Leaves.	Sugar.
	Pounds.	*Pounds.*	*Per cent.*
Ordinary seed, special culture	100	52	13.2
Ordinary seed, ordinary culture	100	28	11.8

"Other tests gave—

Sugar in roots.	Weight of leaves per 100 pounds.	Sugar in roots.	Weight of leaves per 100 pounds.	Sugar in roots.	Weight of leaves per 100 pounds.
Per cent.		*Per cent.*		*Per cent.*	
15.4	58	14.7	62	13.5	36
15.2	63	13.1	31	12.4	25
14.1	52	13.8	26	11.8	26

* La Betterave à Sucre.

† Annales Agronomiques, t. IV, 380.

‡ *Ib.*, t. III, 98

§ La Betterave à Sucre.

"These are the principal external characteristics which seem to have an influence upon the composition and value of the beet, and for the description of the varieties finding greater favor in France and most extensively grown we shall quote from the writing of Mons. H. Vilmorin:

"It is generally admitted that the saccharine richness of beets is inversely proportional to their volume. Taken in a general way this proposition expresses a truth, but it is certain that selection judiciously applied may cause a variation of this relation, and enrich a given race of beets without diminishing either the volume or the yield. It is in modifications of this kind that we should seek the practical improvement of the beet, and the end proposed is to create, at different degrees of the scale, races of beets uniting with a given yield the maximum saccharine richness compatible with that yield.

"The search for a beet which shows at the same time a maximum of product and a maximum of richness is a chimera, and the sooner its pursuit is relinquished the more will disappointment and useless endeavor be avoided. In fact, high saccharine richness is necessarily allied to a great abundance of leaves and rootlets, and beets rich in rootlets and leaves can not become voluminous without becoming deformed and losing the external qualities of regularity and cleanliness which are in a great measure indispensable to a good race of sugar-beets.

"Starting out, therefore, with the idea that the different circumstances in which the manufacturer or the grower finds himself placed demand different beets, let us examine the really known varieties and what they may become under the influence of skillfully applied selection.

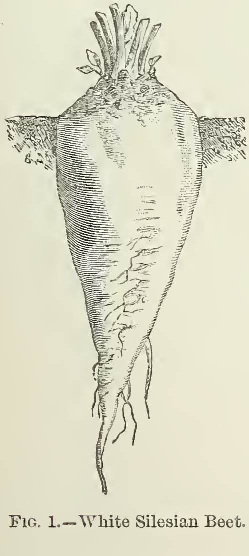


FIG. 1.—White Silesian Beet.

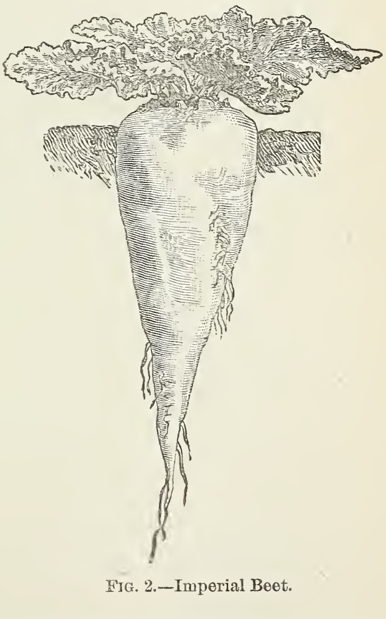


FIG. 2.—Imperial Beet.

"The White Silesian sugar-beet (Fig. 1), origin and point of departure of all the other varieties, is still preferred above all in a large part of Europe. It is a race of medium size, almost entirely buried with white skin, slightly wrinkled, leaves rather spreading than erect. It is rich in sugar, generally containing 12 to 14 per cent. Its yield in good conditions is about 20 tons per acre. It is perfectly adapted to close culture, and does not require very deep soils. Cultivated in France for some years, it has increased in volume, and has come to yield easily 22 to 23 tons per acre. Now that there is a tendency to return to beets rich in sugar, the *acclimated white German* beet is one of the varieties most recommended.

"Of this there exist several sub-varieties, obtained by selection. We cite among the most distinct the *Magdeburg*, rather small, but long and very regular; the *Breslau*, shorter and more swollen; the *Imperial* beet (Fig. 2), obtained by Knauer, which is long, regularly tapering, having the form of a carrot, foliage light-colored, curly, and approaching the ground; the *Electoral*, of the same origin, more (gonflée) swollen, larger, and more productive, but slightly less rich than the *Imperial*.

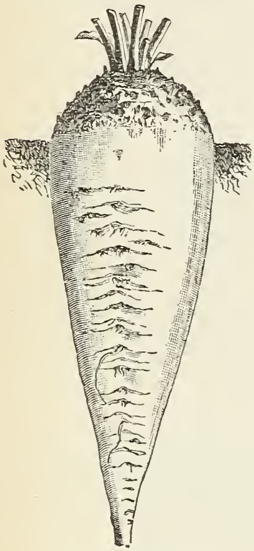


Fig. 3.—Green-top Beet.

"The *green-top* sugar-beet, a French race (Fig. 3), is in much less favor to-day than it was fifteen years ago. It is, however, an excellent race, larger, better formed, and smoother than the Silesian beet. The top, which protrudes from the earth a few centimeters (a couple of inches) only, is colored green; the root is long, smooth, and white. This variety may give as high as 25 tons per acre, containing from 11 to 14 per cent. of sugar. Manufacturers who have continued to cultivate it have had reason to be satisfied with it. We have known its yield in sugar to be as high as 3.69 tons of 2,000 pounds per acre.

"The French *pink top* beet (Fig. 4) is that which has been most generally grown for years. The favor accorded it is justified by a collection of qualities which seem to make the race the most advantageous of all, in the ordinary conditions of the culture of our country. In fact it unites great vigor, which admits of its yielding 28 to 30 tons per acre, with a generally regular form and a very satisfactory richness, which varies from 10 to 13 per cent. of sugar; it is at the same time capable of easy preservation. The foliage is vigorous and abundant, and the top protrudes slightly from the ground in such a way as to facilitate pulling without diminishing the saccharine quality of the root. The largest yields per acre we have ever known have been obtained with this variety. We have known a production of 3.95 tons of sugar per acre.

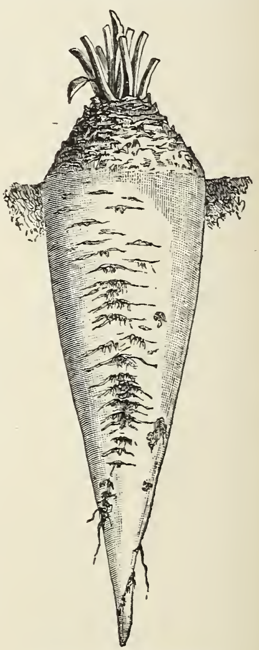


Fig. 4.—Pink-top Beet.

"The *gray top* beet or the *pinkish gray* beet of the North (Fig. 5), is of all others the most perfect as to form and the most productive. It has but few leaves, and very nearly one fourth the length of the root is above ground. This part is gray, greenish, or brown; is clean and smooth like the buried portion, which is more or less pink. On the other hand it is the least rich of all the sugar beets, and is at present almost universally proscribed by manufacturers. We believe the sentence rather severe, because the gray-top beet is capable of giving, by means of a suitable culture, yields of sugar per acre which rival those of other races, and we believe it may be sufficiently improved with regard to the richness without losing its qualities of form and volume.

"The white improved Vilmorin beet (Fig. 6) descended directly from the white Silesian, was brought by Mons. L. Vilmorin, by means of selection, to present, after several generations, a richness of 15 to 18 per cent. of sugar. This has been its condition for long years, and experience proves that it would be chimerical to endeavor to obtain greater richness, because the plant would then cease to grow with sufficient force. Efforts have tended in these latter years toward the improvement of the form and increase of the product, and important progress has been realized in this direction, since the improved beet, which was represented at the beginning as giving per acre a product of 8 to 10 tons, containing 15 to 16 per cent. of sugar, has given in late yields of 18 to 20 tons per acre with a richness in sugar varying from 15 to 18 per cent.

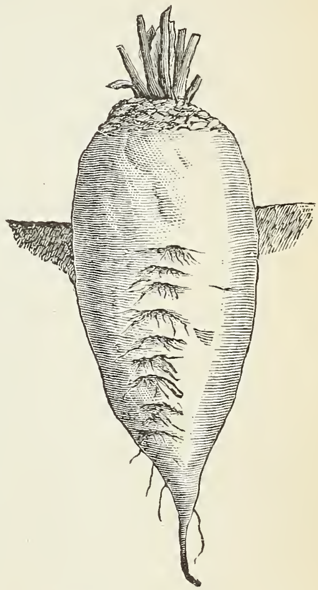


FIG. 5.—Gray-top Beet.

"This race has always been considered particularly suited to special conditions of culture and manufacture which are not those of France; it seems to us, however, that, in consequence of the modifications to which it has been submitted in later times, and which have increased its volume and its yield, it may be adopted in certain cases, even in our country. By growing it very closely, the inferiority of its volume as compared with that of other races is in great part compensated for, and on the other hand it has been proven by numerous analyses, especially in the competitive exhibitions of beets at Arras and Senlis, that this race surpassed all others, not only in saccharine richness, but also in the purity of its juice, which contained less of ashes and salts than that of any other variety, an advantage of very great importance.

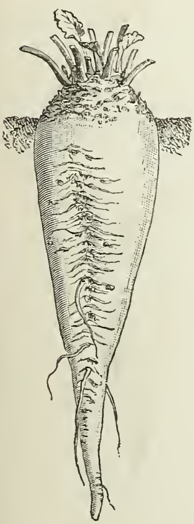


FIG. 6.—Vilmorin's Improved Beet.

"This brings us to the consideration of the internal structure and composition of the beet, which, like the external characteristics, may naturally be modified by the conditions of culture and nutrition to which the plant is subjected.

"The structure of the root has been the subject of careful study by M. Decaisne, the able director of the Department of Vegetable Physiology of the Jardin des Plantes at Paris, and he has made a complete microscopic examination and consequent description of the minute anatomy, but in this report we shall notice only those physical characters which are manifest to ordinary vision, and the relations they bear to the economic value of the root. It is this part of the subject that has been worked up by Payen, who called attention to the appearance of the alternate opaque and transparent bands when the root is sliced in the direction of its longer axis, and of similar zones when cut in the direction of its shorter axis. Of these, he shows that the former or opaque zones are the richer in sugar, and in his memoir on this subject he says:*

"If a root be cut in the direction of its length and through its center, it shows the section represented in Fig. 7. *b b b* are the parts containing the sugar. They are distinguished by their more decided white appearance; all the tissue which separates them is grayish, and contains little or no sugar. This is proven by chemical tests, by cupric liquor among others, or even simply by the taste.

"Champion and Pellet state † that—

"If very thin slices of pink beets be used, after a few minutes' exposure to the air, the zones pointed out by Payen may each be subdivided into two different zones, separa'ed from each other by a series of black points (tubes) distributed in the form of circles, and seeming to correspond with the leaves.

"The structure would then be as follows: 1, opaque zone; 2, transparent zone; 3, opaque zone; 4, zones of vascular tissue.

"The formation of these zones seems to be in some way allied to the production of leaves, as well as the increased proportion of sugar contained in them, for Bretschneider noticed a relation between the number of leaves and of the concentric layers, and Gaudichaud found that 'the leaves of beets correspond directly with the different zones of vessels in the roots in such a way that the appearance of new leaves should always give rise to new zones of vessels;' while in connection with the above facts Champion and Pellet give the following figures, showing the relation between the percentage of sugar in the juice, the number of leaves on the plant, and the number of zones in the root:

Seed used.	Sugar per cent. per volume.	Number of leaves on root.	Number of zones.
Vilmorin seed	15.7	42	48
	14.8	39	36
	13.8	31	32
Ordinary seed of the factories	12.2	23	28
	11.5	19	20

"Payen's notions found support in the results of examinations of the parts made by Joulie, Violette, and others. Notwithstanding the earlier statements of Violette, he has published results of analyses showing that the percentage of sugar in the several parts varies inversely with the distance of the part from the longitudinal axis, and that the higher percentage is found in the opaque zones. Thus the same beet gave the following figures:

	Per cent.
Translucid zones	14.5
	13.4
	10.0
Opaque zones	15.7
	15.5
	11.2

* Comptes rendus, xxiv, 909. Quoted in Traité de la Fabrication du Sucre, by E. J. Maumené, t. I.

† La Bettrave à Sucre, p. 58.

“In his earlier work, Violette found little difference in the quantity of sugar present in the two kinds of tissue, but the notions then obtained from it with reference to the location of albuminoids and salts have re-

FIG. 7.—Vertical section of beet root to show anatomical structure.

ceived full confirmation in his own later work and in that of Professor Joulie. Thus, he stated—

> The former (the translucid zone) appears to contain the higher proportion of mineral matters. The proportion of chlorides may be eight times as great; organic, nitric, and phosphoric acids are about equivalent, but sulphuric acid is much more abundant in the sacchariferous tissue, probably on account of the predominance of the albuminoids.

The distribution of the albuminous matters and salts is shown in the following statement giving the composition of the translucid and opaque zones:

Zones.	Sugar.	Ash.	Saline quotient.	Nitrogen of normal matter.	Nitrogenous matters of normal matters.	Nitrogenous matters per 100 of sugar.
				Per cent.	*Per cent.*	
Opaque zones	11.27	0.63	5.5	0.263	1.643	14.5
Translucid zones	10.00	0.84	8.4	0.230	1.430	14.3

Violette also found a higher percentage of sugar in the lower portions than in the upper portions of the root, and Joulie found that the tops contained less of nitrogen than the lower extremities. Thus Violette, cutting the root in several slices, beginning at the top, found them to contain, respectively, of sugar the following percentages:

	Per cent. of sugar.
First slice	10.42
Second slice	10.54
Third slice	10.70
Fourth slice	10.80
Fifth slice	10.94
Sixth slice	11.11
Seventh slice	11.33

And Joulie found:

	Per cent. of nitrogen in normal matter.	
Tops	0.30	0.295
Extremities of roots	0.33	0.260

The relation between the nitrogen and the sugar content of beets has been completely confirmed by the further results obtained by Professor Joulie in the analysis of beets grown under different conditions, as illustrated in the following table:

	Richness of beets in sugar.	Nitrogen in beets.
		Per cent.
From plots having received no nitrogen	12.55	0.264
	13.58	0.308
	15.24	0.515
Plots having received 57 pounds nitrogen per acre	11.06	0.352
	11.59	0.387
	12.97	0.429
	14.98	0.472

"This relation exists not only in the structure of the root, but also in the juice after its extraction.

Relation between content of nitrogen in the beets and in the juice.

Sugar in beet.	Parts of sugar in 100 of juice.	Parts of nitrogen for 100 of beets.	Parts of nitrogen for 100 of juice.	Nitrogenous matters for 100 of juice.
Per cent.				
14.4	16.0	0.45	....	....
13.9	15.5	0.37	0.29	1.88
13.9	15.5	0.45	0.21	1.33
12.4	13.7	0.30	0.24	1.56
11.0	12.2	0.30	....	....
10.4	11.5	0.19	....	....
9.7	10.5	0.17	0.12	0.78

"Or, calculated for 100 of sugar contained in root or juice:

Sugar per 100 grams of root.	Nitrogen per 100 grams sugar in root.	Parts sugar per 100 of juice.	Parts nitrogen per 100 sugar in state of juice.
13.9	2.6	15.5	1.8
13.9	2.9	15.5	1.3
12.4	2.4	13.7	1.6
9.7	1.7	10.5	1.1

"The mineral matters, it appears from the above analyses by Violette, exist in larger quantities in those portions of the root which contain the higher percentages of sugar, but this relation does not appear to hold for entire roots—that is, comparative estimations of sugar and ash in different roots does not seem to establish a lower percentage of ash in roots containing tolerably high percentages of sugar, and that for roots varying in saccharine richness of from 10 to 14 per cent. the proportion of mineral matters present will not vary widely from 0.90 per cent., and this view is supported by the figures given by Champion and Pellet.*

Sugar in beet.	Ash in beet.	Relation of ash to sugar, 100 to—
Per cent.	*Per cent.*	
14.4	1.05	7.2
13.6	1.13	8.2
13.3	0.95	7.1
13.1	0.93	7.2
12.7	1.06	8.2
12.0	0.94	7.8
11.8	0.90	7.6
11.2	0.93	8.2
11.0	0.77	7.0
10.6	1.10	8.1
10.4	0.74	7.1
Average	....	7.6

* La Bettrave à Sucre.

"But this latter relation will not hold good for the juice after extraction, as appears from the following table:

Richness of juice.	Ash per 100 volumes of juice.	Ash compared with 100 of sugar or saline quotient.
16.2	0.78	4.7
14.9	0.81	4.8
14.7	0.73	5.3
14.2	0.78	5.4
13.4	0.77	5.9
13.2	0.75	6.2
12.5	0.77	6.1
12.2	0.79	6.1
11.8	0.76	6.5
11.7	0.79	6.8
11.5	0.80	6.9
10.7	0.73	12.3
9.9	0.72	14.5
9.7	0.71	15.6
8.0	0.76	12.2

"This question of the mineral constituents of the root, and the influence they exert upon the production of sugar and its extraction from the root, is an exceedingly important one and merits careful study. In this report it will be further discussed in the consideration of the fertilizers suitable to the crop, and the time and manner of their application. It is, however, proper to state further here, that, of the mineral matters present in the root, phosphoric acid and the alkalies, which are the most important mineral constituents of artificial fertilizers, that have the most beneficial influence upon the value of the crop, seem in the root to vary with the richness in sugar, the phosphoric acid increasing with an increase of the sugar content, and the alkalies decreasing under like conditions. These facts are fully established in the results of the researches of Professor Joulie, shown below:

	Sugar in root.	Phosphoric acid in normal matter.
	Per cent.	*Per cent.*
No. 1. Plot having received no phosphoric acid	12.97	0.042
	13.01	0.039
	14.98	0.054
No. 2. Plot having received, per acre, 58 pounds phosphoric acid	11.06	0.042
	11.45	0.048
	11.59	0.060
	12.52	0.071
No. 3. Plot having received 116 pounds phosphoric acid per acre	11.00	0.053
	13.24	0.086

	Sugar in root.	Potash and soda in normal matter
	Per cent.	*Per cent.*
Plots having received no alkalies	13.58	0.640
	14.98	0.415
	15.24	0.385
Plots having received 150 pounds of alkalies per acre	11.45	0.494
	11.54	0.480
	13.11	0.291

" But the quantities of alkalies absorbed by the root seem never to exceed a certain limit, as shown by Peligot, Corenwinder, Pagnoul, and Leloup, and it is by no means proportional to the quantities supplied by the soil, and the quantity of sulphuric acid necessary to saturate or combine with the alkalies contained in the ashes of beets will not vary much from 58.5 per cent. their weight. This latter relation has been fully established by the work of Dubrunfaut, Corinwinder, Ragot, Champion and Pellet, and others.

" Not only is the quantity of alkalies that may be absorbed by beets thus limited, but Champion and Pellet have found that the alkalies and alkaline earths, in the absence of those best suited to the plant, may substitute each other in the proportion of their respective chemical equivalents; a fact of importance in the study of the chemistry of soils and fertilizers.

" Of all the qualities of the root, there is none that would afford as ready and easily applicable a means of separating beets of different quality as the density, and this has long been and still is considered by many growers a strong indication of the saccharine value, but the best authorities seem to consider it a doubtful one. Dubrunfaut finds this relation to be materially modified by the presence of air or gases in the root. This view is also held by Champonnois, who, in examining roots produced in the campaign of 1874 to 1875, found that a beet having a density of 1.010 may give a juice having a density of 1.050. The figures given by Champion and Pellet are also adverse to the idea. Examination of twelve beets gave the following:

	Density of roots.	Density of juice.
Four samples	1.012	1.043
Two samples	1.020	1.048
Two samples	1.026	1.052
One sample	1.031	1.050
Two samples	1.033	1.048
One sample	1.038	1.052

" Other tests gave:

Density of root.	Density of juice.	Sugar in juice.
		Per cent.
1.033—1.030	1.058	11.7
1.025	1.056	12.2
1.025	1.052	11.3

" Having now studied the internal structure and characters of the beet and the conditions residing within the root itself, we come to the consideration of the juice, the quantity that may be extracted, and its composition and value. I do not propose to discuss the complete analyses of the juices, but to call attention to some of the later facts that have been worked out concerning the qualities which may affect the value or may aid in determining it. We have seen above that the deposition of sugar in the roots is almost always accompanied by a proportional deposition of albuminoids and salts, and also that the relation found to exist in the root is continued in the juice after extraction. These conditions have an influence upon the separation of the sugar which the experience of the manufacturer has taught him is unfavorable, and they will be called up again in the treatment of the subject of manufacturing processes, but in the present section we desire to call attention more particularly to the quantity of juice that may be extracted, the conditions which may modify it, and the density of the juice as influenced by the proportion of sugar present.

"We now come to the methods of selecting seed and seed-bearers, and the principles upon which they depend. Of all the experiments and investigations in the direction of improvement of this culture, none seem to have made such rapid strides in advance as in this line of work, none have given results more fruitful and of a character so well suited to ameliorate the relations between the producer and manufacturer, and at the same time be a source of profit to both.

"The initiatory steps in this work in France seem to have been taken by Mons. Louis Vilmorin, the former head of the great house of Vilmorin-Andrieux & Co., of Paris, and his methods of working, followed by similar results, are still being prosecuted with rare intelligence and skill by his son and successor, Mons. Henri Vilmorin, whose contributions to our knowledge of this and other cultures have done so much to clear up the many difficulties which surround and accompany the profitable management of the several agricultural industries.

"Of the outward characteristics which aid in determining the richness of beets, we have found the most important, as recognized in France, to be size and form of the root, its density, the number and appearance of the leaves, etc., and all these properties will be mentioned in the general rules for selection. But thus far we have failed to notice the external and internal characteristics of the seed, which have been found to have an important bearing upon the character and value of the crop; and, before proceeding to the effects of selection in securing desirable crops, we shall call attention to the relation of the character and composition of the seed upon the quantity and quality of the roots produced from it. In this connection we must again refer to the valuable little work of Champion and Pellet, in which these authors and investigators take issue with, or rather proceed further than, Walkhoff, who advises selection of the larger seeds for planting because they give more robust plants. This is true as far as it goes, but the authors above mentioned, also finding the relation of seed to the value of the crop to exist, find further that while the larger seeds give roots of larger volume and weight, the smaller seeds give smaller roots, which are richer in sugar. Thus taking two lots of seeds produced by Simon Legrand, one lot having an average weight of 3.2 grams per 100 seeds taken, and another lot having an average weight of 4.25 gram per 100 seeds, the determination of the weight of the roots produced and their saccharine richness gave the following results:

Dates.	Average weight of four roots.	Sugar in roots.
One large seed:	*Grams.*	*Per cent.*
August 11	66	....
August 20	75	11.4
August 31	125	....
September 16	375	11.8
Two small seeds:		
August 11	30	....
August 20	50	12.0
August 31	75	....
September 16	233	12.5

"Dubrunfant is of the opinion that seeds having the highest specific gravity are more suitable for planting than those of lower density. He effects a separation by placing the seeds in water and after a time removing those which float, preserving those which sink to the bottom of the containing vessel. He states that the two qualities of seed behave quite differently both in germination and during growth. Champion and Pellet* quote Basset as saying, 'It is well to do the same for seeds as is done for roots for reproduction, and choose the heavier ones, or those that fall to the bottom of a bath prepared with water and salt.'

"The chemical composition of the seed has also been the subject of study by different chemists.

"Dubrunfant,† by a chemical examination of the seeds taken from a crop of 30 acres of sugar and forage beets, and furnished him by the house of Vilmorin-Andrieux & Co., in Paris, found that the seeds of the sugar-yielding races give upon incineration a smaller weight of ash than the forage races, and the differences, which vary within certain limits, are all, with few exceptions, in the same direction. Comparing weights of seed taken and ashes produced, the proportion for the sugar-forming races varies between 4.50 and 6.50 per cent. The forage races give from 6 to 14 per cent., making an average of 7 to 8, which is very different from the proportion given by sugar-yielding races.

"It also appears that the ash of the sugar-forming races is richer in phosphoric acid, potash, and even magnesia. Thus the seeds of the sugar races give 0.004 to 0.008 per cent. of their weight of phosphoric acid, while the seeds of forage beets gives but 0.0002 to 0.0005 per cent. A similar relation exists for the potash. Thus for the sugar races a sufficient quantity is always present to develop a green color with the manganese in the ash by fusion, while in the forage races this is not the case. But if to the ash of the latter a small quantity of potash be

* La Bettrave à Sucre, p. 29.

† La Sucrerie Indigène, xiii, 428.

added, the characteristic green coloration produced by manganese is readily developed by the application of heat.

"The conclusions of Dubrunfant confirm the results of the analyses of Pellet.*

	Per cent of ash in dry matter.
Vilmorin seed (average)	6.0
Sugar beets	7.4
Forage beets	8.0

"The results of the chemical analyses of the ashes are as follows:

	Ordinary seed of the sugar factory. No. 1.	Ordinary seed of the sugar factory. No. 2.	Improved Vilmorin seed.
Potash	21.1	16.4	24.2
Soda	8.9	10.4	12.8
Lime	25.4	20.2	17.2
Magnesia	13.5	11.5	10.1
Sulphuric acid	4.0	2.8	4.3
Chlorine	4.7	4.1	4.1
Phosphoric acid	8.4	9.3	17.4
Silica	13.4	....	....
Oxide of iron	1.2	26.4	11.0
Manganese	0.7	....	....
Total	101.3	101.1	101.1
Deduction of oxygen for chlorine	1.3	1.1	1.1
	100.0	100.0	100.0

"On the other hand, seeds of rich beets contain a higher proportion of nitrogen than seeds of poorer beets, and at the same time small seeds contain more nitrogen than large ones, as is evidenced by the following results of examinations by Champion and Pellet:

Vilmorin seed.	Weight of 100 seeds.	Water in normal matter.	Nitrogen in normal matter.	Ash in normal matter.	Nitrogen dry matter.	Ashes in dry matter.	Nitrogenous matter in dry material.	Alkalinity of ash expressed in SO^3 HO.	Average sugar in beets.
	Grams.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*
Large seeds	4.130	10.9	2.66	5.4	2.98	6.061	8.6	14.9	15
Small seeds	0.546	11.0	3.07	5.3	3.44	5.95	21.5	13.1	
SUGAR BEET.									
Average of the varieties:									
Graytop, greentop, large seeds	4.745	12.2	2.46	6.5	2.80	7.4	16.8	......	10
German, acclimated, pink top, small seeds	0.777	11.2	2.80	8.2	3.15	....	19.68	....	
FORAGE BEETS.									
Ox-horn, German yellow, large seeds	4.647	12.5	2.38	7.0	2.74	8.0	14.87	13.6	4 to 6
Pink field, red globe, small seeds	0.560	11.4	2.55	9.0	2.87	.....	15.93	12.4	

* La Bettrave á Sucre, p. 31.

" These relations between the richness of the beet and the composition and size of the seeds, furnish the bases of ready and valuable means of selecting the good and separating them from the worthless. The method recommended is to pass them over a screen with meshes of a given diameter, which unfortunately has never been determined, or at least stated, and to throw those which pass through in water or a solution of salt, rejecting those which float. Those which sink combine the valuable properties above described, of small size and high specific gravity. In the processes of selection as applied to choice of beets for production of seed, which really constitutes the production of new races, the end really to be attained is the ultimate development of a race, or of races, which will at the same time satisfy the demands of the producer and the manufacturer; that is, that will give a large yield to respond to the demands of the former, combined with good quality and high richness in sugar to respond to the demands of the latter. In the opinion of some of those who have devoted themselves to this work, the hope of a result such as we have described must be considered almost useless, if we depend upon the root and its characteristics, but much valuable assistance may be rendered in the attainment of this end, as we shall see later on, by the intelligent application of fertilizers to the crop and the methods of culture adopted and employed.

" In the earlier experiments in this line, those of Mons. L. Vilmorin, attention was more especially directed to the production of very rich beets, with no particular care to the size, the desire being rather to obtain beets of small size, with tapering form and smooth surface; but the late work of all engaged in this kind of experiment and research has been directed to the enrichment of races giving roots of larger volume and fuller form, making them better adapted to all soils and all methods of culture. In most cases, therefore, the work starts from the races most extensively grown.

" Vilmorin began his work by following the method employed in Germany of taking the specific gravity of the roots by plunging them in saline solutions of known density, but he soon found that, in consequence of the almost constant presence of an internal cavity, this method was inexact.

" Dubrunfaut further explains the cause of the inaccuracy of this method in the fact of the existence of air and gases within the body of the root. Vilmorin therefore resorted to the method of taking from the center of the root under examination a cylindrical portion by means of a cutting tube, and determining the density of the portion thus obtained, in solutions of sugar of known specific gravity, but these solutions were discarded on account of their unstable character, and similar solutions of salt substituted. But the loss of sugar in the sample by osmosis when immersed in the saline solutions renders this mode of procedure also unsuited to the attainment of the end in view, and he finally turned to the determination of the density of the juice itself as the readiest and most exact means of determining the sugar content of the sample. The sample removed from the beet, furnished on grating and pressing sufficient of juice to admit of taking the weight of a metallic cube of known dimensions immersed in it, from which the density of the juice could readily be calculated. This method of determination he found to give more accurate results than any other when working upon so small a quantity of material.

"It is useless to add [he says in his paper read before the Academy of Sciences in November, 1856] that the temperature taken by means of a thermometer with tenths of degrees is carried on the register after each weight of the ingot, and that the gauge of the vases, the fineness of the suspending thread, and the identity of all the conditions of the operation eliminates errors which at first produced certain irregularities in the manner of working.

"Having thus determined the specific gravity of the juices of the various beets under examination, those considered worthy of propagation are preserved and the others rejected. The surfaces of the wounds produced in the beets examined by the removal of the sample are covered with charcoal dust, which effectually prevents any decay or deterioration in consequence of the treatment to which the roots have been submitted.

"This method was employed in the development of the race of beets known as Vilmorin's Improved, and it is this method or modifications of it, or some additional operations carried on in connection with it, that is employed to-day by the most intelligent and responsible producers of improved seed in France.

"Mr. Henri Vilmorin, who has succeeded his father in the work, combines the method with examination of the sample of juice, after the determination of its specific gravity, by means of the polariscope, while others employ, as supplementary to the method, estimation of the sugar by means of the copper test.

"But notwithstanding the unfavorable conclusions concerning the method of selection, based upon the density of the roots as determined by immersing them in solutions of molasses or salt of differing but known strengths, it is still used by many of the leading seed-growers in the north of France. M. Demiatte, in an article on the subject of selection of seed-bearers, states* that he proceeds as follows, according to Brabant's method: Select subjects weighing at least 700 grams (1½ pounds). For determination of their density they are thrown into a vat partly filled with a solution of molasses, having a density of 2.5 degrees by the densimeter; those roots which float are rejected; those which partly sink are preserved for the production of seed called No. 3. Those which sink completely are thrown into a second vat containing a solution similar to that just described, but having a density of 3.5 degrees. Those which float here are preserved for production of seed known as No. 2. Those which sink to the bottom are of course of the best quality, and are used for production of seed No. 1.

* Journal des Fabricants de Sucre, 1879, February 19.

"We have seen that the generally adopted opinion concerning the best form of beet to be chosen for production of high yields of sugar is to the effect that the long tapering ones are the most valuable; but this opinion is likely to be subject to modification in consequence of the results of later observations upon the constitution of the improved varieties and their power to resist the deteriorating influences to which they may be subject in the varying conditions of soil and culture. The tapering, richer, improved races, descended from German stock, have been found more subject to disease in France than the poorer races of the country, and M. Decrombecque, at Lens, conceived the idea of incorporating within the latter the sugar producing-qualities of the former, and at the same time retaining the hardiness for which the commoner races are well known. To attain this end he had recourse to the method suggested by Walkhoff,* who believed that the saccharine richness of beets may be improved by crossing, and who was able by using seeds of Frickenhouse, and the method referred to, to obtain beets the juice of which marked 18.8 degrees, Balling, and containing 16.5 per cent. of sugar, starting with varieties the juice of which showed but 17.8 degrees, Balling, and containing 16.35 per cent. of sugar. In planting, the roots were placed in close contact so that the blossoms touched each other, and the slightest agitation was sufficient to effect the transport of pollen.

"But the results of the experiments and of the practice adopted by Mons. Decombrecque † are rather more striking than those obtained by Walkhoff. He noticed when he began his work at Lens that the Silesian beet grown upon a rather shallow soil, and especially when manured with stable manure containing considerable straw, in the spring (well known to be a bad and injurious practice), was hairy, fusiform, and wanting in weight. At the same time the white beet of the country, with green top, gray flesh, and obtuse form, flourished and developed well, though remaining pyriform in the same field in which the Silesian fared badly. The question was to produce a beet having the hardiness of the one and the richness of the other. He chose from his crop the best formed, richest subjects, of *size above the average*, well covered in the ground, and then, observing the same care, chose specimens of the country roots called *toupie* (about the poorest of all the beets grown), and the beets thus chosen he preserved for seed. In planting he combined them in the proportion of five plants of the Silesian with one of *toupie*. In collecting the seed he carefully preserved separately that from the Silesian varieties and that from the toupie, and in subsequent sowing used only that from the Silesian. He found that the character of the Silesian beet had changed, and that the beet had the obtuse form. However, after the third year of planting the modified seed, he found that the good qualities of the Silesian had disappeared, and he had only the low-grade beet of the country. His subsequent practice, therefore, was

* See *La bettrave à sucre*, par Champion and Pellet. † *La sucrerie indigène*, xii, 434.

to grow two or more acres of Silesian, and from the crop produced to select those he needed for seed, and these roots he mixed with roots from the ordinary crop in the proportion of 1 to 3, and thus secured continuously the hardiness of the one and the richness of the other combined.

"With the indications given by Mons. H. Vilmorin in his description of the leading races of beets grown in France, and the methods described in the preceding pages, it will not be difficult for the prospective grower to determine the varieties that will be best suited to his purposes, or to produce new races through which the results he desires may be obtained, but it will not be out of place here to call attention to the experiments of Mons. Derome at Bavay (Nord) made with seeds obtained from various producers with a view to the determination of the best varieties for cultivators to grow in order to secure a crop of quality and quantity to be satisfactory both to themselves and the manufacturer. This he conceives to be a variety that will give the most sugar per acre, in condition to be most easily extracted in the greatest weight. Without entering into the details of his experiments we shall simply give in the following table the names of the varieties of seeds sown and the results obtained:

Varieties.	No. of plants per acre.	Yield per acre.	Density at 60° F.	Gross yield in sugar.	Price of beets per ton of 2,200 pounds.	Sum realized by the grower per acre.	Sugar of 88° extractable.	
							Per 100 pounds of beets.	In quantity harvested per acre.
		Tons.*	°	Per ct.			Pounds.	Tons.*
1. Long pink toupie	23, 205	20. 1	5	8. 431	$4. 00	$80. 00	4. 69	0. 94
2. Silesian, pink, fusiform	34, 210	18. 0	5. 70	10. 766	4. 64	83. 00	6 84	1. 23
3. Silesian, pink, fusiform	32, 388	15. 9	6. 40	12. 841	5. 64	81. 00	8. 34	1. 33
4. Silesian, white, first choice	32, 344	11. 9	7. 15	13. 769	6. 80	78. 00	9. 27	1. 07
5. Silesian, white, second choice	32, 266	16. 0	5. 95	10. 921	4. 94	79. 00	6. 84	1. 09
6. Silesian, white, acclimated	35, 060	15. 9	6. 10	11. 473	5. 16	32. 00	7. 34	1. 16
7. Silesian, white, acclimated	34, 656	14. 9	6. 15	11. 194	5. 48	65. 00	6. 97	1. 04
8. White pink top	37, 627	16. 8	5. 75	11. 538	4. 70	79. 00	6. 50	1. 09
9. White improved	32, 759	11. 4	7. 20	11. 368	6. 92	78. 00	8. 68	0. 99
10. White green top	34. 210	15. 3	5. 90	10. 912	4. 88	73. 00	6. 89	1. 05
11. Pink acclimated	31, 983	13. 8	5. 90	10. 736	4. 88	68. 00	6. 67	0. 92
12. White silesian	32, 874	14. 2	6. 10	11. 126	5. 10	73. 00	6. 93	1. 98
13. Pink silesian	33, 966	15. 1	6. 05	10. 825	5. 08	79. 00	6. 69	1. 01
14. Pink silesian	33, 400	17. 9	5. 45	9. 957	4. 36	78. 00	6. 02	1. 08
15. Pink Brunswick	31. 583	17. 5	5. 40	9. 709	4. 32	75. 00	5. 86	1. 02

* Of 2, 200 pounds.

"He concludes from the figures obtained and here given that the best beets to be grown, and which he considers the races of conciliation, are those represented by the numbers 2, 3, 5, 6, 7, 8, 10, and 14. If sold according to the density of the juice and the scale of values in the form of arbitration adopted by the sugar manufacturers at Lille,* the grower will receive a higher return per acre than with any of the other varieties mentioned.

* See later on in discussions of relations between the grower and manufacturer.

"In this connection the results of the experiments of Deherain are relevant and interesting. He says:*

"It follows from our experiments and analyses that beets submitted to different modes of feeding or fertilizing, preserve in their development the native qualities of the seed, *i. e.*, their race.

"In several of the experiments, pink tops and improved Vilmorins were submitted to exactly the same conditions, same sterile soil, same manures given in equal quantities, yet in one case while the pink top contained 7.5 per cent. of sugar, the improved beet contained 16.2. In another case when the fertilizer was more nitrogenous, the richness of the pink-top beet fell to 5.5 per cent. and the Vilmorin to only 13.4. This shows clearly the influence of race upon the saccharine quality of the beet. The conclusions would appear premature were these experiments the only evidences to support them, but they are also confirmed in the results of experiments made by Mons. H. Vilmorin at Verriers, according to Professor Deherain's suggestions.

With reference to the type of beet to be chosen, Mons. Demiatte† says:

"The nature of the soil and method of culture being known, the form should change with the nature of the soil; should be long and tapering in deep sandy or alluvium soils; short and more obtuse in shallow soils like that near Arras, where the thickness of the arable layer will not exceed 6 inches. But whatever be the type chosen the top of the mother beet should not protrude from the soil more than one-fourth its total length.

"With the facts and figures presented, which have all been worked out in France by careful experiment and investigation, no further comments on the different French races will be necessary. The selection of varieties for cultivation can best be left to the reader. We believe, however, it will be of interest, and we shall, therefore, conclude the consideration of this subject by giving the names and addresses of several of the leading producers of seed in France who made exhibition of their products in the late Paris Exposition of 1878, with short notices of the character of their exhibits.

Desprez père et fils, Capelle.—The varieties produced are No. 1, white or pink, containing 15 to 18 per cent. sugar, requiring deep, rich soil, plenty of manure, and excellent culture; yields 16 to 20 tons per acre. No. 2, white or pink, 12 to 15 per cent. sugar, for ordinary soil, fertilizing, and care; yields 20 to 25 tons per acre. No. 3, 10 to 12 per cent. sugar for inferior soils and cultures; yields 25 to 30 tons per acre.

"*Simon-Legrand, Auchy.*—Different varieties containing 12 to 20 per cent. of sugar; some varieties of special selection containing from 20 to 23 per cent.

"*L. Dervaux-Ibled, Wargnies-le-Grand.*—Cultivates seed by special method of selection depending upon taking specific gravities of cylin-

* Annales agronomiques. † Journal des Fabricants de Sucre, February 19, 1879.

drical samples cut from the roots and immersing them in saline solutions of given strength.

"*Brabant frères Onnaing.*—Cultivate seed of special variety bearing their name; claimed to produce 21 tons per acre, of beets of average richness of 14.88 per cent. of sugar.

"*Vilmorin-Andrieux & Co., No. 4 Quai de la Mégisserie, Paris.*—Produce seed from five varieties, given in the table below, showing the industrial value of each variety."

	Green-top beet.	Improved Vilmorin beet.	French races.		German race.
			Pink top.	Green top.	
Yield per acre ....long tons..	33.117	16.639	30.121	30.049	23.360
Sugar, per gallon of juice ....pounds..	1.12	1.63	1.24	1.20	1.30
Sugar, per acre.......................do....	8,437	5,601	8,754	8,595	7,029
Sugar, per long ton of beets	149.6	290.4	182.6	173.8	222.2
Approximate industrial yield..per acre..	4.468	3.095	4.893	4.739	2.308

THE IMPROVEMENT OF THE SUGAR-BEET.*

"'The improvement of the sugar-beet' is a term essentially capable of great expansion, inasmuch as its significance embraces the bringing about of the fullest adaptation of the beet, to the industries of sugar and spirit manufactures, and under very varying conditions on the one hand of the manufacturing process, and on the other of the operation of the tariff laws.

"The question, however, may be so far restricted as to consider one of two purposes—either, according to the laws of physiology and agricultural chemistry, and to the observations of practical experience, by seeking that process which will yield the greatest amount of sugar per acre at a given cost, or by following artificial methods, endeavor by obedience to those, to obtain such beets as will give the greatest profit. By the adoption of one of those courses beets will be grown best adapted to the manufacture of sugar and spirit in France.

"The improvement of the method of beet-production is not more difficult with these roots than in the examples of other plant kinds; in fact, in given respects, it is more simple and stable. It is quite possible to establish given properties and specialities in the beet providing those properties are not in actual opposition to the nature of the plant, and that they are capable of transmission to the following generation. In brief, those given specialities and characters are to be secured by selection. Nevertheless, not every man will succeed in such a course of improvement by selection. It is necessary (1) that the cultivator shall

* By H. de Vilmorin, Sucrerie Indigène, vol. 34, p. 328, and Zeitsch. Rübenzucker-Industrie, October, 1889, p. 888.

have a clear grasp of his purpose, and (2) that he shall be fully cognizant of the nature of the plant and of the conditions of its growth.

"The first of these conditions is a general one and applies to all experiments. The second condition, however, requires a knowledge of the advantages and disadvantages of the varieties chosen for cultivation, and that the conditions of growth shall not be artificially influenced, or at least not in a way prejudicial to the strengthening of the natural proclivities of the plant. The latter condition is of the first importance and demands all consideration. The rules for such experiments in the cultivation may be given as follows:

"(1) The individual plants which are selected for cultivation must be planted under those conditions which allow of the full development of the natural merits and demerits of the variety.

"(2) The experiment plants must, moreover, be grown under the same conditions, in respect of the length of the period of growth, the distance between the single plants, the properties of the soil and fertilizers applied, as the roots grown for the actual making of sugar.

"In order that the size, form, the sugar-content, and the purity of the juices of given varieties may be properly adjudged it is essential that the roots shall have been grown under the conditions in which those several characteristic features and properties could be normally developed. Strange to say, a rule so natural has been consistently ignored, and beets have been provided for purposes of the laboratory strongly at variance with those requirements. The soil has been very deeply cultivated, and the roots grown in the closest proximity in order to produce beets long and thin and free from side roots, and, naturally, rich in sugar—a directly opposite procedure were probably the most reasonable.

"As an example of a bad quality may be given the nature of certain roots, or varieties of roots, to run to seed. Roots for propagating must be selected which are free from this inclination; and, in order to provide a trustworthy test, the seeding must be made very early which thus induces the disposition to 'run.' The plants which do not show the 'running' disposition should be selected for further propagation.

"Another example: How is it possible to sort out the representatives of a very fibrous nature when the roots are grown under conditions whereby the side roots are not developed?

"As the average weight of the roots is a matter of consideration it may be observed that both home and foreign seed-growers aim at the production of beets weighing from 600 to 1,200 grams.

"As the characteristics of beets are several the selection must be spread over, and depend upon, certain different observations. The size, form, color, leaf growth, the season of growth, as well as the period of maturity, are suitable for such observation, and experienced seed-growers will be readily able to make their distinctions from the observation of those several physical properties. The determination of the sugar-content and of the purity of the juice depend upon purely chemical estimations. The specific gravity of the roots and of root-juices is determined, and the sugar quantity is ascertained by means of the polariscope and copper solution. The determination by use of the polariscope is to be preferred for the reason that little time is required and the purity of the juices is observed by the same process.

"It is not enough, however, nor is the main purpose accomplished, when beets have been secured, rich in sugar, of a pure juice, and possessing the several physical qualities which have been specified. The greater purpose is to distinguish those beets in which the given properties and values are fixed, and which are capable of transmitting those specialities to successive generations; in other words—which are true in propagation.

"I have, with great labor and care, endeavored to secure seeds and beets with fixed characteristics by planting the seeds of selected representatives and growing those with the single view to the observation of their hereditary values. At the end of the year those plants which had not preserved the given physical properties were thrown out and the 'true' beets preserved for propagation.

"In my opinion, the problem of securing practically the best beet seeds is to be attained by observing the following means:

"(1) The organizing of the production of beets possessing definite and fixed properties and specialties by the use of the most rigid system of 'selection.'

"(2) A system of cultivation and planting most approved, in view of economy, by sound experience. These rules may encounter considerable controversy, but they are resting upon a long personal experience and the opinions and practices of French and German experts and practical men.

"The growing of seed from small roots—250 to 400 grams—has no disadvantage in respect of the value of the seed; nevertheless this will only apply in the instance where the practice is not repeated with the seed from the same. Seed grown from beets of a large growth can not be so economical as from the smaller size, and when the condition attaching to the use of the smaller beets is observed, no disadvantage occurs.

"Amongst the many most excellent kinds of French beets, one in special must be mentioned, although I may stand in a close relation to its history. The beet was introduced by my father, and I have given all possible care and endeavor to increase the form and weight-producing quality to the highest degree compatible with a proportional increase in the sugar-yielding value of the same. And, in the face of all controversies, I must maintain that no other system of culture would have established and sustained the same excellence of the beet in respect of form, weight, and purity of the juice as the system adopted in our experiments and specified in the rules already laid down.

"Amongst other French representatives may be mentioned the Brabant-beet, whose habit of growth is typified by the upright leaf, long, thin, and smooth root, and distinguished by its richness in sugar. This kind may be classed as one of the best French varieties and distinctly differing from the German.

"Of many excellent German beets which have been introduced into France the 'Klein-Wanzlebener' has had an experience of ten years in our climate and appears to thrive better even than in its native sphere. The variety is known by an abundant leafage of a bright green, and broad, multiplied roots.

"The 'crossing' of different varieties is a rich source of varying kinds, but the course has a fatal effect upon the hereditary principle and properties. The characteristics of the 'cross,' which may be the product of a single year, are transient and may be lost in as short a time as they require to be produced.

"I would specially state that the assertions which I have made in respect of the best beet kinds are not merely devolving upon my own experience, but may be supported by comparison with the statements of other experimenters.

Experiments of M. Dupay in Chervy-Cossigny, given in the year 1888.

	Yield.	Sugar per hectare.
	Kilograms.	*Kilograms.*
Average of four French beet cultures	36.000	5,665
Auerage of four German beet cultures	35.140	5,537

Experiments of MM. Porion and Dehérain—1888.

	Yield of roots.	Sugar in juice.	Sugar in beet.	Money value.
	Kilograms.	*Per cent.*	*Per cent.*	*Francs.*
French	43.100	16.74	14.77	1,659
German	45.100	16.39	14.50	1,623

"The yield is in favor of the German, but the money value is greater actually in the French."

Experiments of the Sugar-House Bourdon (*Puy-de-Dôme*).

	Yield per hectare.	Density of juices.	Sugar per hectare.
	Kilograms.	°	*Kilograms.*
French	44.854	7.9	7,970
German	40.296	7.7	6,979

VARIETIES OF BEETS.

The varieties of beets which are cultivated are perhaps more numerous in name than in distinct qualities. In France the White Improved Vilmorin beet is very largely cultivated. Its general type is shown in the following figure:

FIG. 8.—White Improved Vilmorin Sugar Beet.

This beet has been the result of thirty years of methodic and persevering selection based upon the lines above indicated. In regard to its preservation it is recognized that it holds its sugar content better than any other variety. In those factories in which the Improved Vilmorin is manufactured in connection with other varieties it is the custom to reserve this for the end of the season and to work up the less reliable beets at an earlier date. It is also said to resist better than any other variety the unfavorable influence of certain characters of soil and of certain manures. In black soils, rich in organic matter, it will give great industrial results, while most other varieties of beets become watery or saline in excess. Excessive quantities of nitrogenous fertilizers, which are carefully excluded from ordinary varieties, can be applied with safety to the Improved Vilmorin. A great number of experiments has shown that this can be done without serious deterioration in the quality of the sugar and with a considerable increase in weight. From thousands of analyses it has been established that the percentage of sugar which can be obtained with this variety is about 16. In regard to its yield under favorable conditions it can be stated to be between 30 and 35 kilograms per hectare.

Perhaps more important for general cultivation than the Vilmorin variety is the beet known as the Klein-Wanzleben, which at the present time has probably a wider cultivation than all other sugar-beets. The general character of this beet is shown in the figure.

FIG. 9.—Klein-Wanzleben Sugar-beet.

This beet has a conical root, straight and even, quite large at the head and rapidly tapering. It is distinguished from the Improved Vilmorin by its brighter color and its lighter-colored leaves, which are beautifully undulating or scalloped about the edges. Coming from a cross in which the Improved Vilmorin entered largely, the Klein-Wanzleben is to-day a fixed variety, and is equally well produced in France and Germany. It succeeds equally well in soil of an alluvial nature and mean richness and on level plateaus. In soils very rich in humus it ripens poorly and loses much of its richness. Like the Vilmorin Improved, toward the end of vegetation its leaves are completely spread. In those conditions of culture where the Improved Vilmorin gives 34,000 to 36,000 kilograms, the Klein-Wanzleben will give 40,000 kilograms. It is, however, always inferior to the Improved Vilmorin in point of view of its saccharine richness, which the whiter and more watery appearance of its flesh would make known at first view. Nevertheless from 13 to 15 per cent. of sugar can be obtained in the beet.

The Brabant sugar-beet is altogether different in aspect from the preceding varieties. It is long, rising well above the level of the soil, carrying a foliage vigorous in growth and upright in position. This variety would seem at first view to have come from the white varieties used for forage; nevertheless its great vigor, its abundant production, and its content of sugar sufficiently high make it a beet quite valuable in those countries where the tax is placed upon the amount of sugar made rather than upon the beet. The Brabant Sugar-beet will give easily 50,000 kilograms per hectare and may be made to contain 12 per cent of sugar. Its general appearance is indicated in the figure.

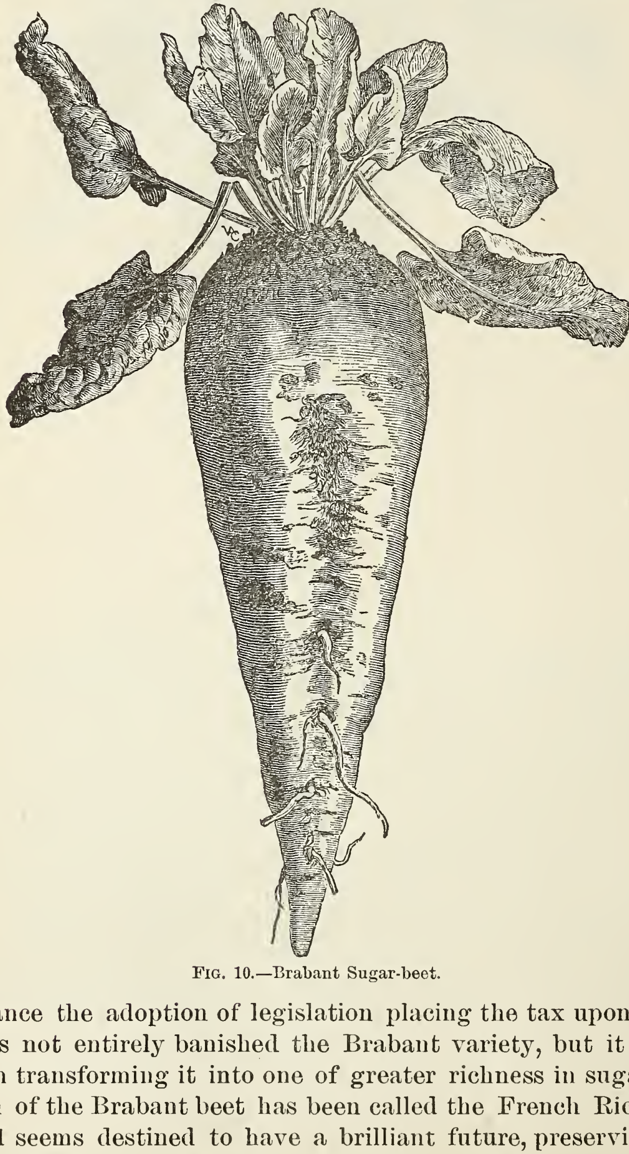


FIG. 10.—Brabant Sugar-beet.

In France the adoption of legislation placing the tax upon the beet itself has not entirely banished the Brabant variety, but it has succeeded in transforming it into one of greater richness in sugar. This variation of the Brabant beet has been called the French Rich Sugar-beet, and seems destined to have a brilliant future, preserving in its general aspect, and notably in its foliage, many of the characteristics of the Brabant. The French Rich Beet differs distinctly from it in the fact that it grows entirely under the soil, is more slender, with a more reddish skin and more compact flesh. Its yield is superior to the Vilmorin Improved and even to the Klein-Wanzleben, amounting to from 40,000 to 43,000 kilograms per hectare in good conditions. Its general appearance is indicated in the figure.

The content of sugar of this new variety is rarely inferior to 14 per cent on the weight of the root.

FIG. 11.—White French Rich Sugar-beet.

The Imperial sugar-beet is one which is largely grown throughout Europe. It has a regular conical outline with a top-shaped top and with leaves with rather short stems. There are different varieties, such as the Old Imperial, Improved White Imperial, and the Improved Rose Imperial. Other varieties which are also grown are the Electoral, the Improved Elite, the Improved Imperial Elite, the Imperator, Olive-shaped, and the Excelsior.

Some of the most celebrated firms in Europe producing sugar beet seed are Vilmorin-Andrieux & Co., Maison Simon Legrand, of Paris; Messrs.

Brumme, of Bernburg, Germany; Dippe Bros., Quedlinburg, Germany; Ferdinand Knauer, of Gröbers, Germany; Le Maire frère et sœur, and Florimond Dèsprez.

BEET-SEED AMELIORATION.

For many years past there has been a constant improvement in the quality of sugar beets raised in France. While it is true that for more than twenty years beets have been grown with high sugar percentages, their irregular shapes and special requirements did not bring them within the practical demands of farmers.

The best method of selection is yet an open question, and the seed-growers do not all agree as to the most desirable size of the "mother." Some use roots weighing about one-fourth pound, and several agronomists maintain that 2 or even 3 pounds (?) is not too heavy a weight. While in the latter case the seeds attain their full development (whether this is the case with the smaller types it is difficult to decide), many experiments appear to prove that there is very little difference in the seed in the two cases.

Pellet recommends that "mothers" be planted very close together, with the view of preventing any further development of the root, and so that the entire vitality of the plant may be expended in this seed development. Another argument in favor of very small beets is, that there is an economy of space, and the planting may follow on the soil that had already yielded a crop the same year; the expenses also are less.

One argument is that the "mothers," with their numerous stalks, require room, and hence the importance of roots of a certain size and planted at reasonable distances apart. On the other hand, the stalks of small beets attain a far greater height, owing to their desire (so to speak) to derive from the air the oxygen which close spacing certainly keeps out. Again, some assert that with large roots and stalks the size of the seed and quality is inferior to that obtained with the smaller roots. These facts are mentioned simply to show how very difficult is the question of selecting and ameliorating existing varieties of beets.

Peligot, Leplay, Pellet, etc., have concluded upon some interesting facts respecting the requirements and the changes "mothers" undergo during the process of seed formation. The stems, leaves, and seed, yet green during July, do not contain sugar in their composition, but the sugar of the "mothers" constantly diminishes from the time the second growth commences until the seeds are matured. The density of the juice diminishes in the root and increases in the stalks, then in the leaves. Vegetable acids, with potassic or lime base, exist in the juices of the root and stalks.

Respecting the potassic and lime salts, there appears to be an ascending movement between the soil and the stalks, leaves, etc. Carbonic acid in the mean time undergoes the same changes as it does during the first year's vegetation. An interesting fact is, that the requirements of vegetation for potassic and lime salts during the second year is very much greater than during the first year's growth. These salts in combination with vegetable acids, in solution, appear to have important influences on the formation and quality of the seed obtained.

As early as 1850 Vilmorin called attention to the possibility of selecting beets, by depending upon the proportion that exists between the density and the sugar percentage. The classification was very simple, and consisted in placing the roots in solutions having a specific gravity known in advance, prepared with chloride of sodium and water. The selection, according to the density of the juice, followed; but while the results were more satisfactory than the foregoing, it was faulty, and it does not necessarily follow that the richest beets are those having juices of the highest specific gravity. The roots resulting from this selection were very irregular in shape, and could not be used in the factory; they were also difficult to harvest.

The size of the neck, shape of the leaves, their abundance, etc., were elements to be considered in the outer characteristics of selection. M. Desprez's selection has demonstrated that beets which have been selected according to analysis will result in seed-yielding beets testing 2 per cent more sugar than those which have not been analyzed. Some years since it was customary among many seed-growers in France to send seed to Germany and receive them back from that country to France. The roots raised from those "mothers" were selected; a change of climate was *supposed* to have been beneficial.

Twenty varieties of seed were experimented upon by Desprez; all had been produced upon the farms. It was noticed that beets penetrated the soil very much more during a dry than in a wet period. An abnormal number of beets went to seed the first year (42 per cent.); this means a large amount of sugar; it is contended, however, by some that this loss is never more than 2 per cent. Beets of considerable length and having rough skin gave the largest yield, and were but little affected by insects. The observations on influence of distance between beets in rows upon the sugar percentage and yield are worth recording.

It was concluded that upon an average soil there should be cultivated about seven to eight beets per square meter; on well prepared soils with suitable fertilizers the number could be twelve to fifteen. The spacing between roots should depend upon the soil and fertilizers used; selection of the best variety best suited to a given locality also depends upon these factors.

Without doubt the most important beet-seed exhibit at the Paris Exhibition was that of M. Legrand, who devotes annually 50 to 55 acres to seed-raising. Most of this seed is used in the vicinity of his farm and the remainder is sold for a nominal sum, considering the quality and the pains taken in selection. "Mothers" exhibited were much larger than those shown by other exhibitors, and yet the sugar percentage was in some cases over 20. An important fact is that in the selection no beet is accepted unless it weighs at least one pound.

The beets are taken from the field by a harvester, with the view of avoiding bruises which occur with use of spade, etc. This work is performed by the farming hands, who make at once a preliminary classification. Circular piles are formed with leaves outside to protect them from any changes in the weather; but soon as possible these leaves are removed and a second and more complete assortment follows; then the roots are placed in small silos. The laboratory selection by the Violette method is carried out on a most extended scale, there being made 2,500 analyses per diem, and a total of 175,000 during the season of 1889. When in 1885 the raising of superior beet seed was determined upon, the roots on M. Legrand's farm did not test on an average over 11 per cent sugar, and now the standard has reached 16 per cent.

M. H. Sagnier, a well-known agricultural expert, says that during a recent visit he found that two-fifths of the total roots raised by M. Legrand tested 15 to 17 per cent sugar, two-fifths from 17 to 18, and one-fifth had a saccharine percentage beyond the latter limit. The richest beets are known as "grandmothers," and are used for the production of seed which is planted alone for obtaining "mothers;" those of the second category are used for the same purpose. The seeds from the lateral stalks always give the finest grain. Before the flower appears the central and lateral stalks are pinched off, resulting in a greater development and vitality of those remaining; and even before the "mothers" are planted the extreme end of their necks are sliced off.

There can be no doubt of the importance of this extended system of analysis, with the view to a scientific selection, as carried on by Legrand. A member of the jury at the Paris Exhibition, however, reproached the seed-grower in question for the trouble he had taken, as the shapes were so regular that outer signs alone would have been sufficient to decide the quality. There appears to be no limit of time or amount of money that can deter Legrand from obtaining the desired results in beet raising; and his methods, while in many respects original, are destined to have a great future.

In discussing the history of the sugar beet it is too frequently asserted that the best varieties have a German parentage; we are assured that the original types, as adopted by Legrand (who has constantly in mind a beet possessing considerable density and yet juicy) has been obtained after years of careful selection from "mothers" of French origin entirely.

On the Carlier farm the "mothers" are taken from the best fields that are sown in April, and a cultivator is used four to five times before thinning out; eighteen to twenty beets are grown to a square meter. The first selection is made on the field at once after harvesting, the regular shape and size, denoting maturity and quality, being the main basis for the preliminary selection. The roots chosen are silotted near the laboratory, and the second selection is made in January; the beets preferred weigh 350 to 600 grams. For many years it was argued that the greater the density of the beet the higher its saccharine quality, hence a selection offered no difficulty. Later experiments soon demonstrated that such methods were not reliable; as a preliminary operation, however, there can be no reason why baths of salt water or molasses, having a known density, could not be used, throwing aside those roots which would float in the bath of 1.045 density, and keeping, say, three piles from 1.045 to 1.050, from 1.050 to 1.055, and from 1.055 to 1.060.

The classification as adopted by Carlier, depending upon the density of a core taken as a sample from the beet, was not entirely satisfactory; frequently the volume of air, etc., a beet may retain in its composition is to be considered. According to Dubrunfaut, beets retain 115 cubic centimeters of air per 1,000 grams in weight, and frequently there is, owing to this fact, considerable difference between the density of beets, considered as a whole, and the juice. At the Wargine-le-Grand farm these variations were shown to be:

Density of entire beet.	Density of juice.
1.012	1.043
1.020	1.048
1.025	1.052
1.025	1.056
1.030	1.058
1.038	1.052

This fact alone would condemn any method of solution depending upon density.

In the Lemaire system of selection roots weighing 500 to 800 grams have preference; such as remain well under ground, and having a special depression on both sides, commencing with the neck and ending with the tip end. Legrand, Lemaire, and others attach considerable importance to these outer characteristics, and many maintain that the more pronounced they are the higher will be the saccharine quality of the root.

Lemaire and others also maintain that their careful selection by outer signs, combined with chemical analysis, has enabled them to create new types; in fact, most seed-growers may claim that their special varieties have been "creations." The beets in the latter case are placed in silos, where they remain until February or March. The experimenters last named and others consider it a mistake to commence analysis sooner, as there would be no certainty as to the preservation of the roots, a quality as essential as the sugar percentage. The one without the other has but little importance, as they both may be transmitted to their descendants.

When we consider that beets must be kept in silos frequently four to five months before being used at the factory, the element of preservation becomes of the first importance. Those roots which have undergone little or no change in their saccharine percentage during the several months of preservation are selected, and there is very little doubt that just as their conservation was satisfactory so will be the beets raised from the seed they furnish.

M. Lemaire informs the writer that experiments were made with seed from beets having lost in sugar during their silotting and were compared with seed from those that retained their sugar percentage. The conclusion was just as expected; the roots from seed that kept well had a higher sugar percentage than others. The hereditary quality of beets should be constantly borne in mind in these selections and ameliorations.

M. Lemaire also states that all analyses made by the copper test are repeated with the polariscope, and in most cases their seed give roots with a high co-efficient of purity. The "mothers" when planted are placed at distances of 60 to 70 centimeters. About one month before maturing the tops of the highest stalks are cut off so as to permit the sap to center itself upon the seed. Laurent-Mouchon has had some little reputation of late years, his beets being of a satisfactory quality. Their selection does not differ from that above mentioned.

To give some idea of the importance of growing forms of seed as above described, we may mention that the Legrand estate at Besny has over 200 acres planted in beets for the factory at Loan, the yield averaging 10 to 12 tons to the acre, and roots testing from 12 to 16 per cent sugar. About 55 acres are devoted to seed-raising; 3,600 roots ("mothers") are planted to the acre. In the Desprez seed producing farm wheat follows the production of "mothers" in rotation; barn-yard manure, rags, etc., are also used to the value of $10 to $130 per hectare. It is considered that the "mothers" absorb two-thirds of the fertilizers, the other one-third remaining for the wheat. Of the farming lands two-fifths are devoted to beet seed cultivation, two-fifths to wheat, and one-fifth to beets, flax, etc. All soils used for beet cultivation are worked to a depth of 35 centimeters. Soils intended for the "mothers" are worked in two operations, about 20 centimeters in depth in the fall and the remainder in the spring, so as to plow under the fertilizer.

The "mothers" when growing have the cultivator passed between the rows four or five times. The area under cultivation at Orchies is 432 hectares, of which 150 hectares are under Carlier's direct supervision, 54 hectares in "mothers" for seed, and 30 hectares in beets of inferior quality intended for cattle feeding. Efforts are made to keep these separate so that there will not be hybrids formed by the combination of their pollen. The Lemaire plantation at Nomain consists of 275 hectares, in five farms, on each of which a special variety of seed is produced. Besides this 400 hectares of beets are controlled for an agricultural distillery. The annual production here is estimated at 500,000 to 600,000 kilograms of beet-seed.—(The Sugar Beet, vol. 10, No. 4, 1880.)

SOIL, PLANTING, AND CULTIVATION.

PREPARATION OF THE SOIL.

Land which is to be planted with beets, if manured with farm-yard manure, should have this coating applied in a well-rotted state in the autumn and plowed in to the depth of 5 or 6 inches. In the spring the soil should be plowed to a greater depth, from 8 to 10 inches, and if the subsoil be at all hard a subsoil-plow should follow, loosening the subsoil to the depth of 12 to 15 inches. The surface of the soil is then reduced to the proper tilth by harrowing, and, if necessary, rolling to break up the clods. It should not be forgotten that much of the cultivation of the beet may be accomplished in this way before planting and the process of seeding should not begin until the surface of the soil is in the perfect condition mentioned above. Care should be taken not to apply fresh or unrotted stable manure, or any other manure containing large quantities of undecomposed organic matter, to a field seeded to beets except in the manner described above.

It is scarcely necessary to add that care must be taken in plowing the soil to have it in the proper condition of moisture, since, if plowed too wet, it is likely to bake, and if too dry clods may be formed which will be difficult to reduce to the proper state of tilth. A field prepared as above will afford the beet opportunity for growth downward, thus preventing its being projected above the surface of the soil. It will also guard the beet against the dangers of excessive moisture or drought, as stated above.

SEEDING.

In small plots the beet seed can be placed in the soil by hand. For large fields drills are provided which are built to operate precisely on the principles of ordinary grain-drills, the opening for the seed made to correspond to the size of the beet seed. Simple drills may be used or compound drills for planting the seed and distributing fertilizers at the same time, such as are used in sowing wheat and other cereals. A convenient drill for this purpose is represented in Fig. 12, the Planet, Jr., No. 2 seed drill, made by S. L. Allen & Co., Philadelphia.

Distance of rows.—No definite rule can be given for the space between the rows of beets. In an ordinary soil this space should be about 18 inches. In very fertile soil the rows should be placed closer together, in a less fertile soil farther apart.

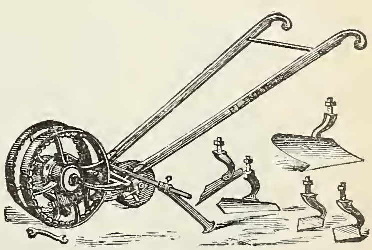


Fig. 12.

The distance at which the beets should be placed from each other in the rows also varies according to the nature of the soil and climatic conditions. In general, it may be said that there should be one plant for each 6 inches.* In very rich soils the beets should be closer together, and in very poor soils they should be farther apart. With rows 18 inches apart, the beets planted at a distance of 6 inches in the rows, the number of beets per square yard would be twelve and the approx-

* The beet seed should be planted close together. Some authorities recommend fifteen pounds per acre.

imate number of plants per acre, 49,000. Supposing that each beet will weigh 1 pound, this will give a yield of $24\frac{1}{2}$ tons per acre. The above conditions may represent a fair average beet field under favorable conditions, although it must be admitted that the average yield of beet fields does not reach so high a figure. If, however, there is a complete stand of the plant, so that every space is occupied, with a fair soil, properly prepared and cultivated and supplied with a proper fertilizer, the above yield can be secured. In every case, however, an attempt should be made to plant the beets close enough together to secure a matured plant, after the separation of the head and tops, weighing about 1 pound. This is found to be the size which best secures a high content of sugar with a large yield of roots, and therefore represents conditions most favorable both to the farmer and manufacturer.

IMPLEMENTS FOR CULTIVATION OF SUGAR-BEETS.

Any ordinary plow may be used for preparing the land for sugar-beets, care being taken that the ground be evenly and completely broken and at an even depth. Instead of plowing to the depth of 12 to 15 inches in the first place, it is best to use the first plow to the depth of 9 or 10 inches, following with a subsoil-plow to the depth of 4 or 5 inches. A subsoil-plow suitable for this purpose is manufactured by the Moline Plow Company, of Moline, Ill., and its general character is shown in Fig. 13.

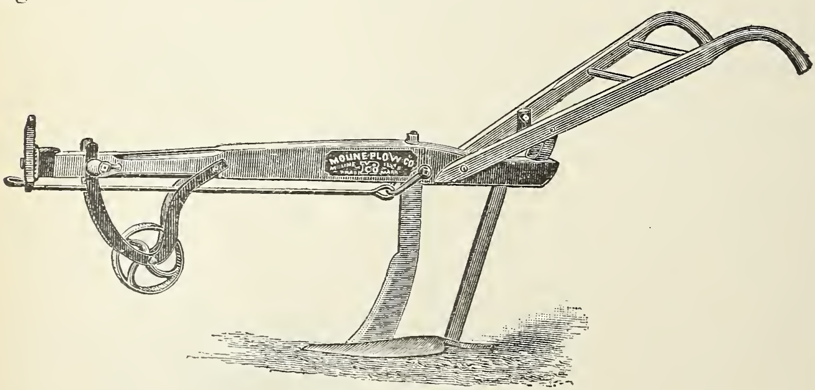


FIG. 13.—Subsoil-plow.

It is often convenient to have the plow and subsoil-plow combined in the same instrument, thus saving the labor of one man. So little subsoiling is done in this country that very few such implements are to be found in the market. A plow of this kind, largely employed in France, is manufactured by Bajac at Liancourt (Oise), and its general form is shown in figure 14.

The subsoil plow is removable, and when the instrument is to be used as an ordinary plow it can be taken off. In plowing with subsoil attachments care should be taken to make narrow furrows, so that the whole subsoil may be loosened and not left in a series of trenches. In no case, in plowing for sugar beets, should the furrow be wider than the cutting capacity of the plow itself. Any good harrow can be used for reducing the plowed land to the proper tilth, and no description of this instrument will be necessary in this place.

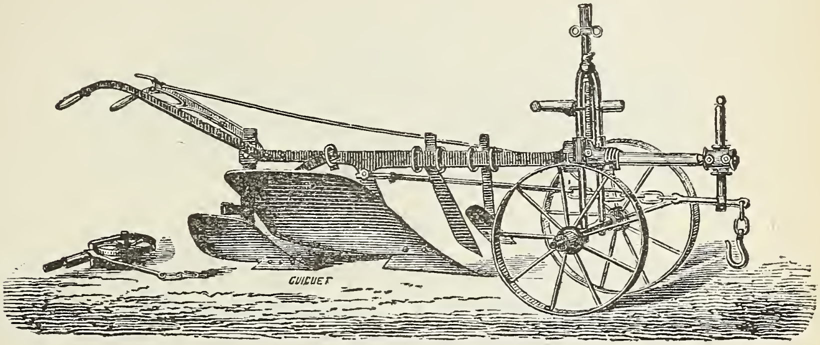


FIG. 14.—Subsoil-plow, attached to plow.

For planting the seed it is best, in small patches, to do it by hand, or by the implement represented by Fig. 12, but when large areas are to be sown in beet seed, power drills should be provided. A drill made by the Moline Plow Company for cotton seed can be easily adapted for use with beets. This is shown in Fig. 15.

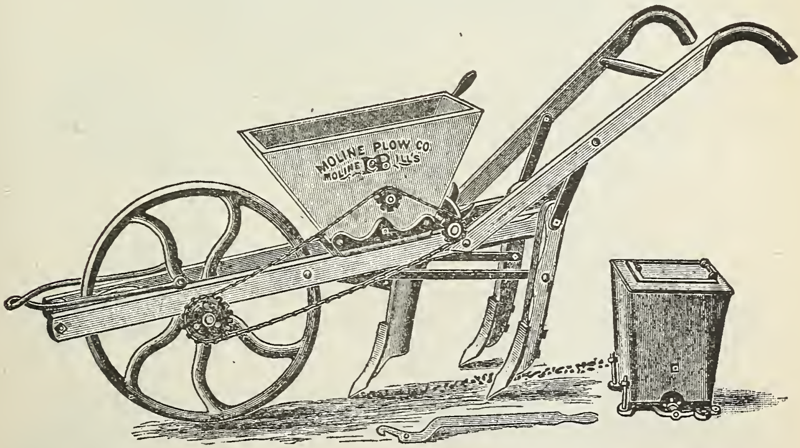


FIG. 15.

An ordinary drill for planting Indian corn can also be easily adjusted for planting beet seed. Great care, however, should be taken in drilling the beet seed not to cover it too deep, and all drills should be adjusted so that the average depth of the seed shall not be more than 1 inch.

In addition to the hand-hoe, Fig. 16, for early cultivation, the horse-

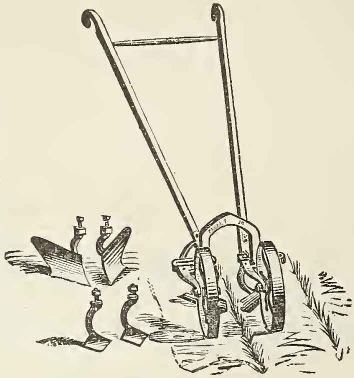


FIG. 16.

hoe manufactured by Bajac can be used with great advantage. Its general construction is shown in Fig 17.

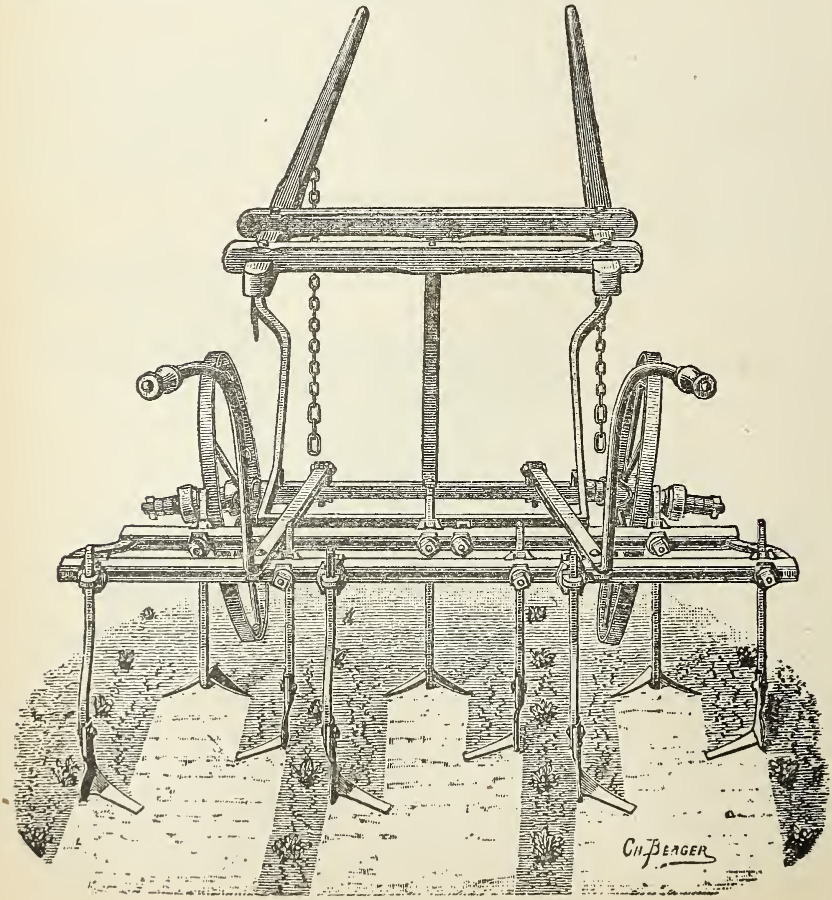
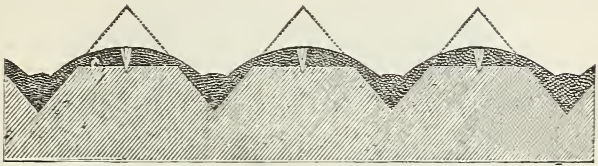


FIG. 17.—Horse-hoe for sugar beets.

Other forms of apparatus used in cultivating beets are shown in the following figures, 17 to 21, inclusive.*

Bertel's ridger, drill and cultivator.



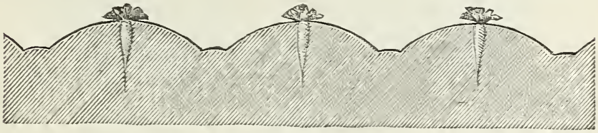


FIG. 18.—Ridges after passage of drill.

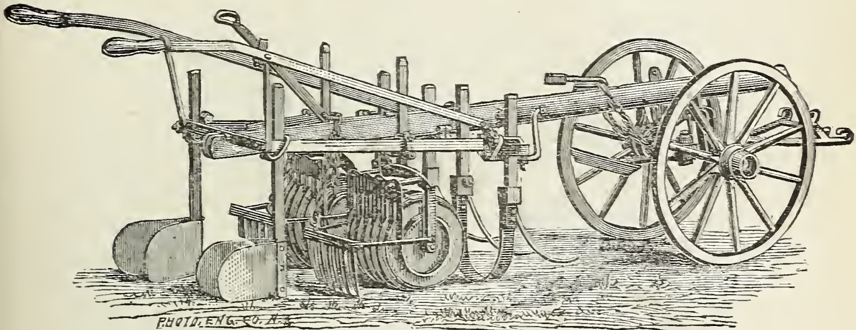


FIG. 19.—Cultivator for working between rows or ridges.

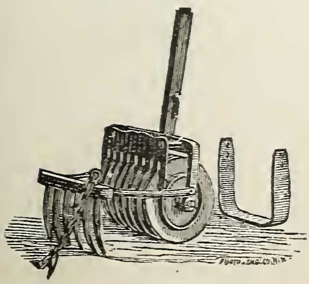


FIG.—20. Scarifiers and rollers for flat culture.

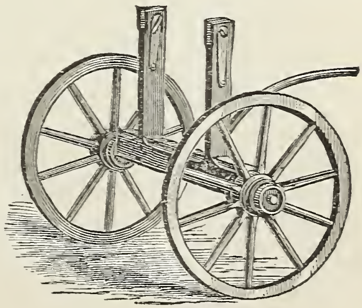


FIG.—21. Leader to cultivator.

* From McMurtrie's Special Report No. 28.

The hoes are arranged so as to cultivate three rows of beets at a time, and are so adjusted as to completely clean the spaces between the rows without throwing any of the soil upon the young plant itself. Inasmuch as each seed of the beet may give one, two, or three plants, form-

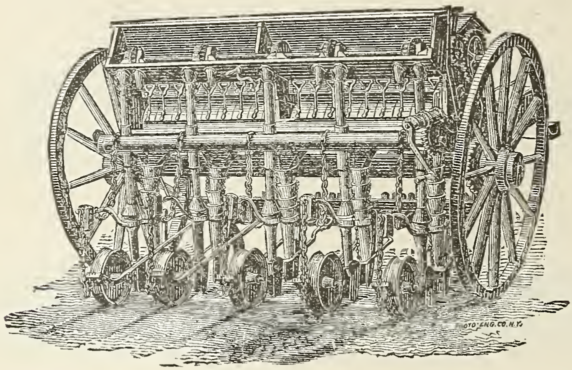


FIG. 22.—Combined beet-seed and fertilizer drill for flat culture.* (James Smyth & Sons, Peasenhall, Suffolk, England). The machine has a range of five hoes 18 inches apart, but the machines vary in number and interval of the hoes, and in price.—(Knight.)

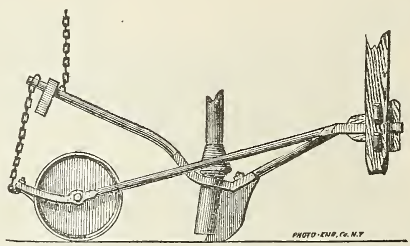


FIG. 23.—Detail of hoe and covering wheel.

ing clusters in the rows, it is necessary that the thinning should be done as carefully as possible without injuring the plants remaining in the soil. It is best that the planting should be close together so as to give a large excess of beets, since in case replanting is necessary it will be noticed that the replanted beets, are uniformly of poorer quality than those of the first planting, and if possible the surplus beet plants should be removed by a sharp-cutting hoe without touching the one which is to remain. In this way one healthy plant should be left from every 6 to 10 inches in the rows. When the beets begin to show the neck above ground, it is well to throw a little dirt against them so as to form a slight ridge. This can be done by a ridging hoe, such as is indicated in Fig. 24.

* From McMurtrie's special report No. 28.

This hoe, as well as the one mentioned previously, is made by Bajac.

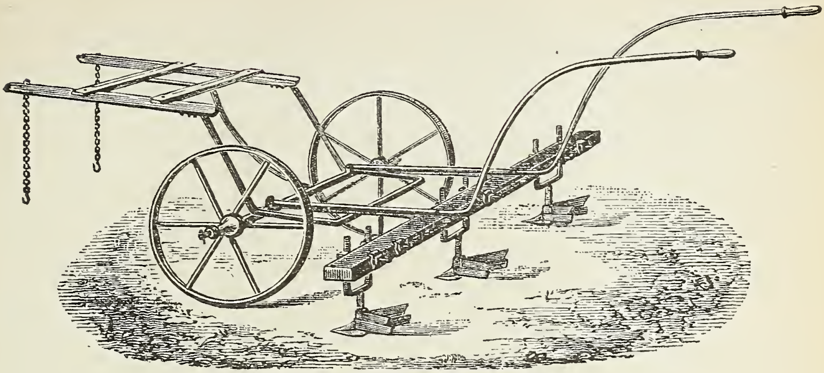


FIG. 24.—Ridging hoe for sugar-beets.

After the ridging is done it is recommended to go between each row with a subsoil plow of very narrow cut to the depth of 12 to 15 inches.

CULTIVATION.

Whatever kind of cultivator may be employed it will be found necessary to protect the young plants from being covered by dirt. Various kinds of shields may be used for this purpose, such as are often used in the plowing of young corn. Sometimes it is customary to cultivate the beets before they are up. For this purpose at the time of sowing a few grains of rye are placed in the furrow with the beet-seed. Rye, sprouting sooner than the beets, marks the rows so that the cultivator may be used as if the beets were already out of the ground. The cultivation should take place at least every two weeks, and oftener if the ground is very weedy, till the middle or the end of June. Unless some shield is used, as above indicated, for the young plants it will be found that many of them will be destroyed by the early cultivation, leaving large spaces unoccupied in the rows, thus giving a smaller yield, and permitting at least a portion of the beets in the fields to grow to an unusual size.

METHOD OF CULTIVATION USED AT ALVARADO, CAL.

The method of cultivation employed by the Alameda Sugar Company, of Alvarado, Cal., has been kindly sent to me by the president of the company, Mr. E. C. Burr, and is as follows:

"Plowing begins soon after the 1st of January and continues until late in the spring, varying according to circumstances of weather and soil. The lands are subjected to two plowings, the first about 8 inches deep and the second to the depth of 12 inches, seldom more, although it would be better in results. After plowing the lands are rolled to break clods, then harrowed and planked with a rude contrivance made of boards.

Rude as it is, it is quite effectual in reducing the lumps and giving the surface a smooth appearance. The preparation of the soil is one of the chief factors for a good crop. The plowed lands are now allowed to stand for a short period, generally a week, until, as farmers say, "the under moisture comes to the surface," an expression which may mean the reverse, for intelligent farmers claim that the lower layer turned to the surface is too cold and damp to germinate the seed readily, and by letting it stand open to sun and air it becomes drier and warmer. After the resting period seeding begins with horse drills, in rows 15 inches apart, and eight rows to the machine, the seeds being dropped in an almost unbroken row in order to induce a good stand. The depth to which the seed is planted varies from one-half to 2 inches, but our instructions this year are to plant one-half inch deep only, as our observations last year showed a large percentage of ungerminated seed at the greater depth, owing probably to too low temperature. As soon as the plants form three or four leaves, that is, large enough to distinguish from weeds, they are thinned out to 4 inches apart in the rows and freed from weeds. In about sixteen to twenty days the second weeding and cultivating takes place. Last year the cultivation part by Chinese labor was a farce, but this year we have introduced some French implements in the shape of "extirpators" and scarifiers which we hope will free the farmer from the Chinese, and do the work more effectually. The "extirpateur" we imported from Mr. H. Amiot-Lemaire of Bresles, France, and which, acting similar to a harrow, is intended to loosen the soil to a depth of 8 inches. The scarifier, as its name implies, is to go between the rows and destroy the weeds. It is built like our cultivators, but with entirely different blades.

"Last year the cultivation was flat, but with the new implements there will be more of a tendency to ridges. The farmers use no fertilizers as yet, although they would be benefited thereby. Were this company raising its own beets, I should certainly insist on it. Yet the lands so far seem to show no deterioration. Last year the whole State suffered from drought and our crop was meager in consequence.

"The average number of plants per acre was 57,000. The average weight per root, topped, on the highlands near Centerville was 121 grams; near Alvarado, on lowlands, the weight, under same conditions, was 307 grams. There is no agreement between the number of roots per acre and the weight. The estimate was carefully made when the first weeding and thinning was done, for roots per acre, and the weights were determined at the factory from every load delivered. In July, near Centerville, the roots ceased growing and we worked hundreds of tons of beets no larger than a cigar. In some places the yield was not over two tons per acre. Of course, under these circumstances, many roots did not mature.

"The methods of farming here must be altered to a very great extent, but it is very difficult to convince the farmers and will take time to effect. We hope during the current year to make some improvement, and shall continue our system of obtaining data. Two men are constantly in the field (one a chemist) from the time the first seed is given out until the crop has matured, and they survey each man's plot, estimate the number of roots per acre, obtain weights weekly of beets with and without leaves, and make weekly tests of sucrose, non-sugar, quotient, etc., from each man's parcel. They also note method of cultivation, condition of crop, etc.

"The sowing begins toward the end of March and continues, working from the highlands to the lowlands, until the middle of May.

"The crop matures about August 15, and is all at the factory by December 1, our storage capacity being for about 6,000 tons only. We tried some experiments with beets in cold storage, but the figures are not before me. One test is worth noticing. We tested beets which had been continuously overflowed from December 1 to March 1 and found them to contain 14 per cent. sucrose, with a quotient of 84 per cent."

DISTANCE AT WHICH SUGAR-BEETS SHOULD BE PLANTED.

Formerly the author had recommended that beets should be planted so that there should be about 10 plants to the square meter. Since, however, the change of law in regard to the taxation of beets requires that they should be grown with great saccharine richness he recommends that they be planted so as to have from 15 to 20 plants per square meter. In this way a beet of great richness can be secured, while the quantity produced per hectare will remain about the same as when only 10 plants per square meter were cultivated.*

METHODS OF CULTIVATION IN BOHEMIA.

The methods of cultivation used in Bohemia are described by Commercial Agent Howes, as follows: †

"PREPARATION OF THE LAND.

"The sugar-beet needs well-cultivated land. First, a surface loose and fine, which allows the air to enter and facilitates germinating and swelling; second, deep, loose, uniform soil, because the beet should develop a slender root without side rootlets. Both can be obtained only by good cultivation. Cultivation differs according to the soil.

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* A. Ladureau, La Sucrerie Indigene, Vol. 33, No. 23, p. 582.

† Consular Report pp. 248 et seq.

"The following suggestions are of value: Loosen the subsoil without bringing it to the surface. If the subsoil be not good, this is doubly important. The depth should be from 30 to 40 centimeters, and a plow similar to that shown in Fig. 25 should be used.

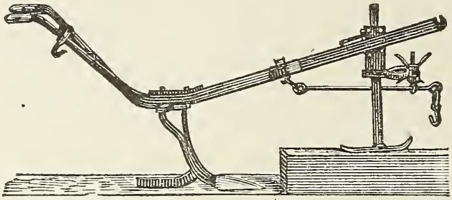

FIG. 25.

"To begin deep plowing, 30 centimeters will be deep enough. After several years it may be made 40 centimeters, but should be deepened only gradually, because, if too much dead soil comes up, the land is ruined for at least one year. Deep plowing should always be done before winter, so that the frost has time to work on the soil.

"*Steam plowing.*—By the introduction of the steam-plow an implement was put in the hands of the farmer, the work of which can not be equaled. The reasons why the steam-plow works so well are—

"(1) By the speed with which it operates the soil is well mixed and pulverized.

"(2) The depth of all the furrows is the same.

"(3) It plows to any depth, especially in heavy soils which would require a large number of animals. Generally the soil is loosened to a depth of 35 to 50 centimeters, and the plants are enabled to take nourishment from a larger quantity of soil.

"(4) In dry seasons soils plowed by steam retain longer their humidity. In wet seasons the water descends quicker to the subsoil. The steam-plow increases the crop and renders it certain.

"(5) The animals leave foot-prints (four oxen make about three hundred and sixty thousand in plowing 1 hectare), and therefore cause a not unimportant loss.

"(6) It is possible to work in spring and fall, when with animals it would be impossible.

"(7) A large number of animals can thus be used for other purposes.

"If we consider that with a steam-plow 3 hectares can be plowed in a day, while with a common plow one-third of a hectare can be gone over, then nine common plows are needed to do the work of one steam-plow; and, as four oxen are needed for each plow, thirty-six oxen would be employed, and, as they should be used only half a day, seventy-two oxen would be required, and their work is not equal to that of one steam-plow.

"The excellent work of the steam-plow can increase the crop of beets from 4,000 to 5,000 kilograms per hectare. The cost of plowing by steam is between $11 and $16 per hectare for a depth of 32 to 40 centimeters.

"Deep plowing can be done in such a way that two plows go one after the other, the first cutting 15 to 20 centimeters deep and the second 10 to 18 centimeters.

"Another way to loosen the deeper soil is as follows: The land is plowed from 15 to 20 centimeters, and laborers then spade up the deeper soil from 20 to 24 centimeters, the undersoil being scattered over the surface. This method is expensive, but produces very good results.

"Still another way to procure most of the advantages of deep plowing, and one which is generally used on very heavy soil or on lands exposed to inundations, which consequently dry at a late period, is to form ridges.

"This is done in the following manner: The land is plowed in the fall in such a way as to form a ridge. For this purpose a hill plow is used, or a machine invented by Dr. Bärtel and called a 'ridge former.'

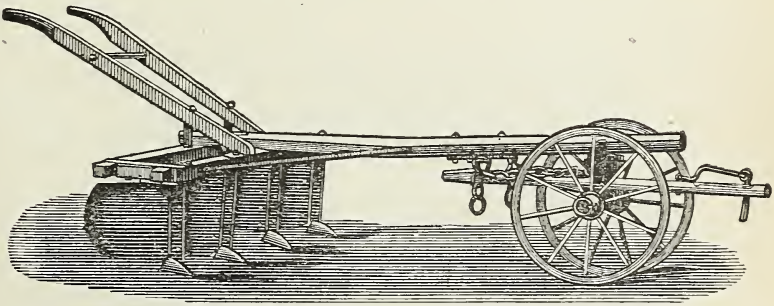

Fig. 26.

"In spring these ridges are split, and thus new ridges are formed. These must be rolled to an even surface.

"The advantages of preparing the land in this way are: The water gathers in the furrows and runs off; the soil in the ridge is always in a good condition and the air can penetrate it.

"If grain has been grown on land about to be planted in beets the preparation goes on in the following way: The stubble is plowed as

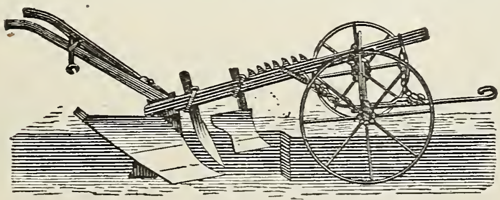

Fig. 27.

soon as possible to a depth of 5 to 8 centimeters. For this work gang plows, as shown in Fig. 27, are used.

"As soon as weeds come up the land is harrowed and rolled. Before winter the deep furrow is plowed, and, if stable manure is used, it should be applied before the middle of November. In such cases only a moderately deep furrow is needed, because, as before remarked, the manure thus decomposes better.

"The land remains in this state during the winter, and is therefore exposed to the influence of frost, rain, etc. In spring it is ready for the beets. Then, as soon as possible, it should be harrowed. The harrows used are, if the land is crusted, 'The Extirpator,' or, if necessary, it must be plowed 15 centimeters deep. Then the "Acme" harrow is used.

"If sugar-beets follow beets, potatoes, or corn, the land is simply plowed before winter.

"Before planting all land should be rolled.

"PLANTING.

"The time of planting influences the crop in a high degree.

"It is shown that in a warm, dry season the crop of an early planting is larger than in a cold, humid season. The time of planting is the middle of spring, with a temperature of from 9° to 12° C. (48° to 54° F.) Early planting begins with April and lasts until the end of that month; late planting is in May. In general, early planting is to be preferred, because the danger from frost is not so great as that of drought. It should always be remembered that the seeds should be put in a soil warm enough to germinate in six or eight days, not twelve to sixteen days, as is the case in cold, humid soil.

"*Distance apart.*—This has a great influence on the crop and the quality of the beet. The experiments of Vilmorin show that the largest crop will be grown if the beets be planted comparatively near together. If the distance increases, the proportion of leaves increases. The lighter and poorer the soil the further must the beets be planted apart, and experiments show that this influence is greater than that due to manuring, or even the choice of the variety. Distances vary from 30 to 50 centimeters from row to row, and from 10 to 25 centimeters in the row.

"*Depth for planting.*—The seeds need only a very light covering—2 to 3 centimeters is the right depth. If part of the seeds are not covered at all, it does not cause so much damage as if they are covered too deeply.

"CULTIVATION.

"From the time of planting up to that of harvesting the following suggestions should be observed: As soon as the sowing is done the roller must be used, because in pressing the surface the humidity, which is very necessary for the process of germinating, is drawn by capillary attraction out of the deeper soil, and the surface is thus kept moist. The roller may be smooth or have rings; the latter is better, because it makes the surface of the land rough, and therefore a heavy rain can not form a crust. If, after sowing, a crust covers the field, the ring-roller is the best implement for breaking it, and after this a light harrow is recommended. Thus is the soil loosened, the air can enter, and germinating and growing are facilitated. When the plants have grown so that the rows are visible, hoeing must be done, and the earlier the better, not only because the weeds are destroyed, but also because the plants need a loosened soil. The oftener the plants are hoed the better will be the crop as regards quantity and quality. Indeed, quantity and a high sugar percentage can only be obtained by hoeing. The first hoeing must be only superficial, that all the weeds are thrown on the surface to dry, and care must be taken that no soil covers the young plants. The hoeing should be done even if the land be dry, as hoeing prevents the evaporation of the water from the deeper soil. If laborers can be had, it is preferable to first hoe by hand in such a way that only the soil about 50 centimeters distant from the beet is hoed and the soil between the rows is untouched. This is then hoed with the cultivator. If hoeing must be done by horse-power, the cultivator shown in Fig. 28 is used.

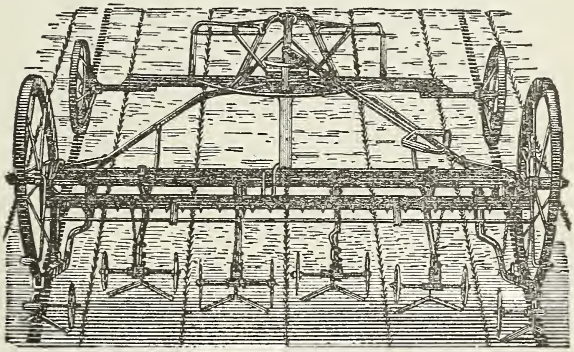

FIG. 28.

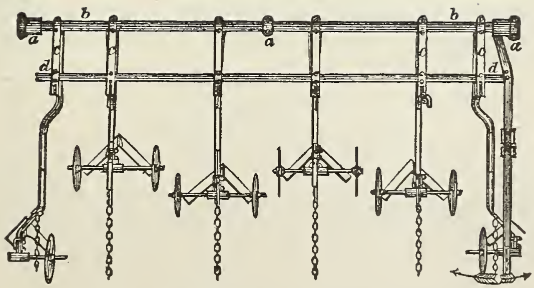

FIG. 29.—View from above of same machine.

" After the hoeing comes thinning out. This must be done as early as possible, and generally, plants sowed by the Dippel machine must be thinned out earlier than those planted by the drill, the reason being that the latter have more light and air than the former. It is practical to thin out when the plants have three or four leaves. The root is then as thick as a straw, and the whole plant has a length of 8 to 10 centimeters.

"If planted with a drill, the work of cultivating can be done in two ways:

"(1) The field is crossed with the cultivator at right angles to the rows, and the knives are set so that they leave about 2.5 centimeters on each side of the beet untouched. Of the plants which remain in this space the weakest are removed by hand.

"(2) The whole work is done by hand. By means of hoes the laborers remove the superfluous plants, leaving spaces about 20 to 25 centimeters between. Children are employed here for this work, as they can best get down to it.

"Cutting the leaves off is not sufficient, as the leaves grow again; or, if not, the plant becomes a harbor for insects. One person can thin out one-ninth to one-eighth of an acre a day. After thinning, hoeing by hand should follow immediately to loosen the soil around the plants; then, between the rows should be hoed, and the time this should be done depends upon the weeds and the soil. As a rule, the intervals should not be more than a fortnight. A fourth, and possibly a fifth, hoeing would increase the crop. Of course, hoeing can not be done when the plants are large enough to be damaged.

"Hilling up now follows. This must be done because, by covering the beets with soil, it prevents the heads from growing out, and therefore this part of the root, which is of no value to the manufacturer, as it contains little sugar, is lessened. Water can run off and evaporate better, and the soil will not become incrusted. In heavy soils this is a very important point. The time for hilling up is important, as if this is done too early the plants are buried, and if too late the leaves are damaged. Hilling up can only be done when the soil is in good condition, *i. e.*, neither too wet nor too dry. For this can be used a plow with a single share, or that already shown in Fig. 29. On small farms it is usually done by hand.

"HARVESTING.

"This is done when the beets are ripe, *i. e.*, when growing stops and all the products of the leaves go to the root, where they are deposited. In Bohemia beets ripen from the end of September to the middle of October.

"*Signs of ripeness.*—The leaves become yellowish green, fall and form a kind of a wreath around the plant. The middle leaves, so-called "heart leaves," also of a yellowish green, do not fall.

"Harvesting should not be too early, as the loss occasioned thereby may amount to as much as 2 per cent. Of course harvesting must take place before heavy frost, though the beet can stand frost from 3° to 4° C. (24° to 27° F.). If early frosts should come, it is best to let the beets thaw in the soil, as the loss will be thus lessened.

"*How harvesting is done.*—(1) By hand. To each man is apportioned a certain tract of land, which he works by contract. The soil around the plant is loosened, and then the plant is drawn from the ground by hand. Work with the fork would be easier, but might injure the beet.

"(2) By team. A subsoil-plow is used, which should be set for a depth of 35 centimeters. A still better implement is the beet-lifter, shown in Fig. 30. This machine can be worked by a boy, and also does not injure the plants which are left loosely standing upright in their places, where they are better protected against sudden rain or frost than if lying upon the ground. As work can be done much faster with the lifter than by hand, this machine will no doubt be of much use in the United States.

"*Cutting off the heads.*—The green heads must now be cut off, as they are of no use. This is done in the field, and here it is the work of women and girls, who accomplish their work rapidly, using sharp knives. About 1 to 2 centimeters of the beet is removed.

"*Piling up the beets.*—This is necessary, as it is impossible to immediately transport an entire crop to the factory, and they must be protected from rot and frost. Perhaps the best plan is that recommended by Knauer, especially if the beets must remain a long time on the field. A ditch 1 foot deep and 6 feet wide is dug, and of the required length. Beets are then piled up with roots toward the center for a height of 1 foot, and covered with 6 inches of soil. Then another layer of beets, covered also, is added, and then another, until the pile, tapering, is of the shape of a prism. If the soil is very dry, water should be applied. Beets so buried will keep six or seven months with little loss.

"It is best to grow only one crop in four or five years on a single field, as otherwise the soil will be exhausted and insects and parasites increase, so that great losses would occur. Beets should follow grain or barley, and after the beet the best crop to plant is barley."

HARVESTING THE BEETS.

The beets may be harvested either by hand with a hoe, spade, or fork, or by simply pulling them from the ground, or by a harvester drawn by horse power. Some advantages are claimed for each method. If the harvesting be carried on by hand, care should be taken that the instrument used should not strike the beet, since it is certain that every time the beet is punctured or bruised a certain loss in sugar will ensue unless it is immediately worked. It is estimated that in harvesting by hand each beet, on an average, will lose from 15 to 20 grams of its weight, or very nearly a ton per acre. For the Bajac harvester figured it is claimed that the beets are entirely loosened from their position, so they can be easily removed by hand with much less danger of being bruised or broken than any other method of harvesting. It is also estimated that by mechanical harvesting a more complete removal of the beets from the soil is secured, since when the harvesting is done by hand many roots are left unnoticed in the soil. According to some estimates from 1 to 3 tons of beets may be left per acre when the harvesting is done by hand. It is further claimed that by the mechanical method of harvesting the beet, being neither bruised nor punctured, is more readily handled for the purpose of preservation, without being exposed to the least source of loss.

It is probable that in this country the mechanical method of harvesting beets will be almost the sole one employed for all commercial pur-

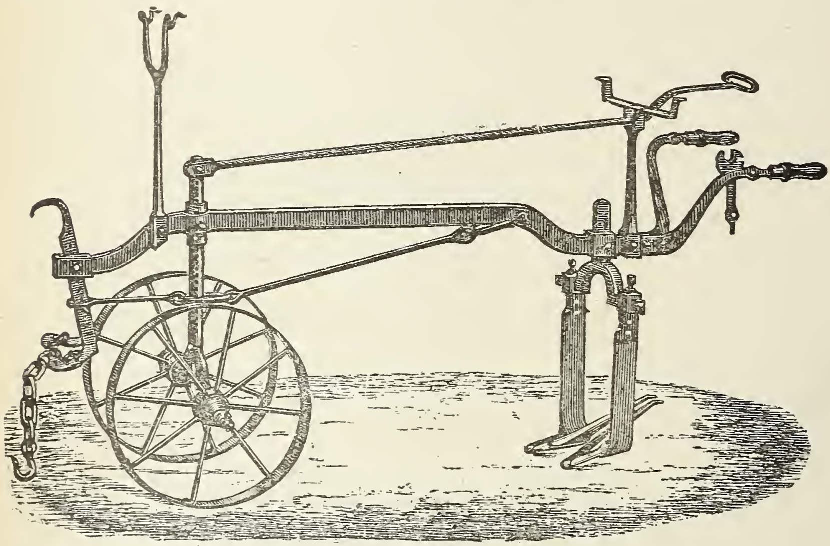

Fig. 30.—Beet harvester for one row.

poses; but meanwhile, where beets are grown only in small quantities and before the introduction of the proper machines for harvesting, it is probable that harvesting by hand will be more common, especially for small plots.

A note has already been given in regard to the time of harvesting, which should begin as soon as the beets are thoroughly matured and before they have an opportunity to take a second growth or be exposed to freezing temperature. In some places in California, as has already been stated, the harvesting begins as early as the middle of August, while in the Northern, Central, and Eastern States it had best be postponed at least until the middle of September, and perhaps better until the middle of October.

Harvesting the beets is best done by implements devised for that purpose, two of which, made by Bajac, are shown in Figs. 30 and 31.

The first one is a machine for harvesting a single row at a time and the second one indicates the beets caught in the prongs of the apparatus arranged for two rows. Harvesters are also built to take three rows of beets at a time.

Mr. Lewis S. Ware, editor of the "Sugar Beet," who attended the Universal Exposition in Paris in 1889 for the purpose of making a study of the sugar-beet exposition at that point, makes the following remarks in regard to harvesting:*

"Beets, like other plants, require a certain number of degrees of heat for their complete maturity. Just when this period is reached is difficult to determine; one fact, however, remains certain, that whatever the theories are respecting outer signs they can not possibly hold good for all conditions of weather, climate, etc. That the leaves are brown

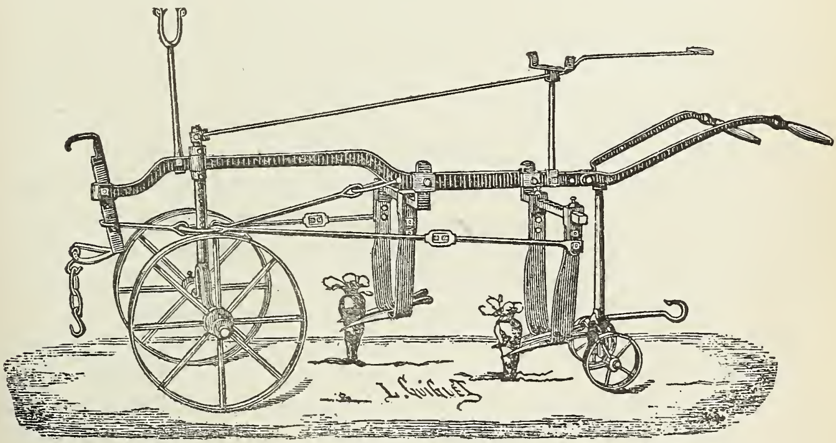

FIG. 31.—Beet harvester for two rows.

or covered with characteristic spots or other indications when the greater purity of juice has been reached must remain very empirical. Many manufacturers have suffered from early harvesting where farmers have depended upon outer signs of the general appearance of the field, such as a yellow or green color, etc. Some agronomists maintain that there exists a proportion between the weight of the leaves and the root, the latter being almost a constant at 65 and 35 for the leaves in a weight of 100 pounds. This can not be a constant, as it varies with the variety of beet. Others contend that a proportion of this kind is more reliable than any system of analysis.

"In France the harvesting occurs at the end of September, and during October cold weather frequently commences. The farmer too frequently considers his own interest, and neglects that of the manufact-

* "Sugar Beet," No. 4, vol. 10, p. 49.

urer; if he leaves the beet in the ground for a considerable period it is solely with the hope that the weight may increase; when this ceases, from his point of view, the roots should be harvested.

"There are, however, cases where experience teaches that certain portions of the field should be harvested earlier than other parts; but unfortunately it frequently happens that hands are then secured with difficulty, and the farmer is unable to furnish the roots at the factory in the best possible condition. One plantation may be in the most desirable condition, while another may not reach the necessary maturity for several weeks afterwards. It necessarily follows, that if the entire crop is harvested at once, it will frequently result in a considerable loss to the manufacturer, and may represent 1 per cent. difference in the yield.

"On small areas special harvesting spades are used, or frequently a sort of fork. The latter has evidently the disadvantage of bruising the root, resulting in a decrease in sugar percentage. Whatever be the method adopted, the roots when taken from the ground are shaken to rid them of adhering particles; frequently the necks are then sliced off, and the roots covered with leaves to protect them from the sun, rain, etc. Many farmers simply make piles of their roots, covering the same with thin layers of earth, awaiting the time for hauling either to the factory or the silos. It has been frequently noticed that there results an increase in the sugar percentage of the roots during the several days they remain in the piles. All the hand methods of harvesting have one important objection, viz, the difficulty of obtaining the full labor of men or women, owing to the fatiguing nature of the task.

"Viallette recommends harvesting with a plow, the coulter being taken off. Two horses are required and the plow is run alongside of the row, about 2 centimeters beyond the beet, throwing the earth to one side; children follow the plow, and collect the roots. The objection to this method is, the fields are always in bad condition after a rain and carting from them is almost impossible. The cost of harvesting with the plow is $7.40 per hectare.

"It has not been many years since the Bajac beet harvester was introduced to the public, and since then it has undergone but few modifications as regards the general working. It is constructed entirely of steel, and is very light and simple in its mechanical working and arrangement. To the fore wheels is attached a well-balanced vertical bar, with a series of horizontal holes, into which is run the pin holding the horizontal shaft for the support of the harvesting blades.

"The blades are made of the very best steel, and are so constructed as to offer but little traction during their working; their penetration in the soil hardly affects the upper surface. The slight slant of the blades, when in contact with a beet, forces it upward, and the operation is completed by a peculiar vibration given, caused by a portion of the blade having an elliptical section. As soon as the implement moves forward, the loosened roots fall back into their respective holes. Under these circumstances, there can be an interval of several days before collecting them for the factory. During this period, as they are not exposed to the open air, there is no danger of second growth produced by rain, etc. The working of the Bajac harvester requires but little experience, and at a few minutes' notice hands are said to be able to handle it.

"The direction of the harvester is determined by a lever within easy reach of the conductor. The depth of the harvesting blades may be regulated according to requirements. It is very evident that the work of this machine is preferable to hand harvesting; not only is it better done, but the cost is very much diminished, and need not be more than $1 an acre, regardless of the distance between rows. Practical experience appears to demonstrate that the saving is about 30 per cent. of the amount harvested. Small, adhering roots not being removed, the beets are in a perfect condition when delivered at the factory.

"Before mentioning other advantages of the implement under consideration, it is interesting to give some even more recent types of the Bajac harvester.

"Owing to the success obtained with this machine it has been suggested that a two or three line implement might render excellent service; both of such are on exhibition. The general arrangement is the same as with the one-line description.

"The work in both cases is very satisfactory, and 4 acres with the two-line implement and 5 acres with the three-line type may be harvested in a day of ten hours. In the latter case the traction is considerable, and requires at least four horses. If, in certain cases, beets are harvested rapidly, the operation may result in considerable profit to all interested. Interviews and conversations with farmers have convinced the writer that the Bajac harvester is the best in existence. Beets over 1½ feet in length are extracted from the soil, which could not be accomplished by any previous appliances. The fact is, we have seen with their tip ends, so to speak, a distance of nearly 3 feet from the neck, taken from the soil after these harvesters had finished their work. When we consider that the richest portion of a beet is that which was previously left in the ground after harvesting, we have no difficulty in realizing the excellent services these implements are destined to render.

"Caudelier's beet harvester appears to be very original in design, and was in use for the first time in 1888. Its work is very satisfactory, and certainly much more economical than could be done by hand. The arrangement of its several parts is calculated for the best results.

"The necessary traction to work this implement is said to be very slight, two horses, however, are required. A fact not to be disputed is, that the soil is very slightly disturbed ; the fore wheels determine the direction of the work and support the working parts. The depth of penetration may be regulated by a screw, while the coulter, placed in front of the harvesting device, opens the soil. This is said to diminish the resistance the harvesting tool and its flat slanting support would offer. The circular disk between the fore wheels slices off the leaves as the row of beets is harvested. Under these circumstances, as is frequently the case, they do not collect against the coulter or form an obstacle difficult to surmount.

"Caudelier had on exhibition another type of harvester much simpler in its construction than the foregoing. The arrangement of fore wheels and attachments permit the slanting of the implement in any direction. In the working of this harvester the beet is scarcely touched, the blade passing under the root without bruising the same."

REMOVING THE NECK OF THE BEET.

The upper part of the beet bearing the stems of the leaves and the part which is most exposed to the sun and light is known as the neck. Before the beets are manufactured it is necessary to remove this neck, both on account of the poor quality of sugar juice which it contains and on account of the large amount of mineral salts found therein. Two methods of procedure are followed. In one case the necks are removed at the time of harvesting, and before the beets are siloed. This method saves one handling of the beets and prepares them at once for washing and manufacture. The other method consists in siloing the beets before the removal of the necks, and postponing this process until they are ready for manufacture. This method is preferred for the following reasons:

When the necks of the beets are cut the juices of the plant escape, including a portion of the sugar, and fermentation is easily set up in the silos. It is therefore probable, on the whole, the beets will be preserved much better in the silos without having the necks removed. According to Bajac (Bulletin de L'Association des Chimistes, April, 1890), harvesting should take place before the beets lose their vigor, and in place of removing the necks and sending the beets at once to the factory, or silo, they should be placed in small piles, together with their leaves, of from 70 to 80 centimeters in diameter and of equal height. These piles should be quite conical and with the leaves turned out. The summit should be covered very carefully, in order that the water and frost may not penetrate it. In place of separate piles, rows of such beets could be established along the length of the field, and being left thus for a fortnight, the beet would finish its maturation with its leaves still attached to it. It would lose scarcely anything in weight, and it would gain in density and, probably, in sugar.

In regard to density, experience has shown that beets harvested on the 20th of September and showing at that time a juice of 1.072 sp. gr. which were preserved with their leaves as above mentioned, gained in six days .006 in density. Experiments carried on for a month from week to week upon beets from the same field, some having the necks cut and the others preserved with their leaves, showed in each instance an increase in density, while the decrease in weight of the whole beet was most sensibly marked in those in which the neck was cut off. Some of these beets exposed to rain on the 20th of November showed some curious phenomena. Those in which the neck was cut had lost .003 in density, while those with their leaves remaining had lost only from .001 to .005. Beets with the necks cut which had been kept for a long time were found almost dried out, while those in which the leaves had not been removed were but little affected.

HARVEST AND PRESERVATION OF THE BEETS.*

"If circumstances of labor, commencement of manufacture, weather, etc., allow, the beets should be gathered at the time when their outward appearance indicates their maturity; that is when the bright green of the leaves gives place to a lighter and more yellowish color and the older leaves wither and fall off. This is a sign that an arrest of the development has commenced and beets gathered then are best adapted for preservation and manufacture even though they may not have the highest sugar content. Beets which are harvested a short time before this period ripen somewhat afterwards in the silo, but generally do not keep so well.

"When the beets are gathered the leaves are cut off and they are immediately covered with earth in small heaps. With beets that are not to be kept very long it is best to cut off only so much of the head as may be necessary to remove the leaves so that they hang together. If it is desired to remove more of the crown it is better to do it in the factory immediately before the beets are worked up. Only at the commencement of the campaign when the beets are taken directly from the field is it advisable to cut off at once all that is necessary. Generally the beets that have been cut close show no tendency whatever to sprout, that is to show leaves in the silo. But their not sprouting is a sign of the cessation of all vegetable life and is generally accompanied by an undesirable change known as "hardening" in the juice, which is more injurious in the manufacture than the development of sprouts, and which latter, if it has not progressed too far, is preferred by the manufacturer.

"Various forms of plows are in extensive use for harvesting the beets; they are indispensable where hand-labor is scarce. They simply loosen the beets in the ground so that they may easily be drawn out, and do not injure the roots.

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* Stammer, *Op. Cit.*, pp. 206 *et seq.*

"The preservation of such beets as are to be worked up during a season extending over several months demands the greatest care and attention to the climatic conditions. They must be protected from frost, which would burst the plant-cells of the beets and cause them to spoil rapidly after being thawed out. Moreover, too much evaporation of the water must be guarded against, as this produces a wilting of the beet, which would have the effect eventually of injuring the juice and the keeping qualities of the roots. Finally, too large piles of beets produces an elevation of temperature which heats them, and the spoiling of the beets follows in consequence. From these requirements it may be laid down as a rule, at least for the climate of Northern Germany, that beets should be placed in heaps or silos whose height and breadth are small enough to prevent the development of heat, and these should be immediately covered with a layer of earth, which should be sufficiently increased from time to time so that frost can not reach the beets. The layer of earth also affords protection against too much sprouting or wilting in consequence of too much warmth. The proper treatment varies somewhat in consequence of differences in climate and peculiarities of soil, but the following general directions may be given as of universal application.

"The beets should not be alowed to lie and wilt after harvesting, but covered as soon as possible. The silos, made as small as it is safe to make them, should point north and south.

"The use of straw is to be avoided except as a temporary protection against wind, sun, and frost, and should then be replaced with earth as soon as possible. Large beets should be preserved in small silos; with small beets the silos may be larger.

"Care must be taken not to damage the beets in putting them away, and injured roots should be carefully picked out. As a winter covering, 3 feet of earth is given in north Germany, though the last foot is not added at once. To facilitate their removal the piles should be arranged lengthwise along the driveways.

"For long keeping the top of the silo is generally roof-shaped, sometimes rounded off; the bottom is made either on the surface or slightly below it. In some cases such a form is chosen as gives a right-angled cross-section. There nothing to show that the form of the silo or the nature of the soil exerts any influence on the preservation of the beets. The size of the silos used varies, and especially according to their situation, whether they are placed in the fields or near the factory. In the east of Germany large silos prevail, in the west small ones seem to be preferred. Breadth and depth vary less than the length; the breadth from 4½ to 6½ feet, the depth from 3 to 6 feet, seldom over 6, and only in a few instances less than 3. Where the silos are sunk below the surface it is generally 1 to 1½ feet, seldom less. The quantity of beets that can be placed in a silo depends principally upon its length, and varies all the way from 6 or 7 tons up to 25 or 50 and more. When placed in the field generally each acre or half acre has its special silo. Generally the contents of the silo are given in running yards of the length of the silo, and are usually about 1 to 2 tons per yard. Where the beets are heaped up according to the Belgian method, the piles hold very considerable amounts, even up to 1,200 tons.

"The covering is done with loose soil packed closely at the bottom, but being less dense toward the top. In the first weeks the top is left open, or very lightly covered, and heaped up when it becomes colder. The thickness of the covering varies from 1 to 3 feet, the latter thickness not being found very generally in the east. The use is sometimes made of other materials, for example, straw, etc. A thin layer of straw is covered over with earth, except at the top of the ridge. Some spread a layer of straw below the beets. It is generally accepted that in the silo a loss of sugar of about 1 per cent. takes place.

"A special method of siloing consists in leaving openings in the earth covering at the sides of the silo to keep the temperature low inside. The objection to this is that the beets quickly wilt around these openings, and that they can not be closed quick enough to provide against a sudden fall of temperature. Some places and climate require especial precautions.

"Babrinsky has formulated the following rules for silos in southern Russia, based on many years of observation and experiment:

"(1) No beet should be further than 1 meter from fresh air.

"(2) For every cubic meter of beets there should be 30 square decimeters of evaporating surface.

"(3) The air in preserving cellars should be daily renewed if it be above 40° F. in temperature.

"(4) Beets do not lose more than 10 to 12 per cent. of their weight by evaporation.

"(5) If the beets are wilted on harvesting they should be moistened with water, and a large number of ventilating canals be built in the silos or cellars.

"According to Walkhoff, in southern Russia the beets are entirely buried in the ground, in a canal with steep, sloping walls. The bottom is covered with a sort of a grate of firewood, on top of which the beets are piled up to within a few inches of the surface of the earth. In the center on top is laid a triangular-shaped wooden gutter to increase the amount of evaporating surface. The whole then receives a covering of straw, which is increased or diminished in thickness according to the temperature indicated by the thermometer inserted. A sort of ventilation is accomplished by canals at the side leading outward, so that at night the cold air may be permitted to enter, while during the warmth of the day they are closed.

"Preservation in cellars is also much used in Russia, according to Walkhoff. These are built to project but slightly above the surface of the ground with their roofs, which are covered with earth. The bottoms are covered with interlaced twigs, and the layer of beets is about 3 feet thick. Ventilation is secured by air-passages in the sides and roof. This method is rather more expensive, but the preservation is better insured.

"It has long been a desideration, so far unfulfilled, to find some means whereby the beets might be protected, on the one hand from the consequences of overheating and on the other from freezing, as well as from too rapid sprouting and from rotting; that is to say, in a good sound condition and without loss of sugar, for some length of time. On account of this not being yet attained, the tendency is to shorten the working season and to increase the quantity worked each day. The discussion of this question and the proper limits to set is of little advantage. It is to be hoped that more attention will be paid to observations on the changes undergone in the silo, upon which improvements in the methods used may be based."

SILOS AND CELLARS.

The following illustrations of silos and cellars are taken from McMurtrie's Report 28. In California silos are not required, and the beets may be preserved in large heaps as shown in Fig. 43:

Preserving trench (Basset).

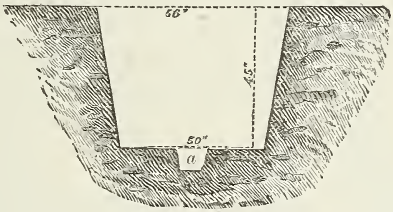

FIG. 32.—Trench open; *a*, drain trench.

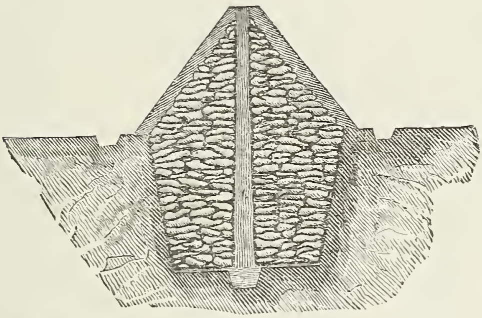

FIG. 33.—Trench filled, with ventilating shaft arranged.

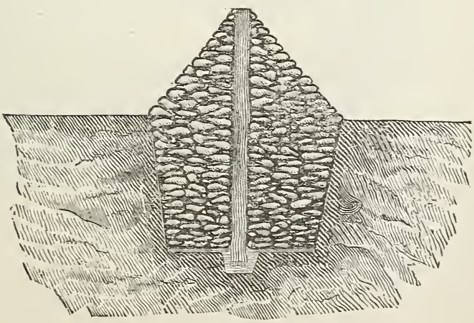

FIG. 34.—Trench filled and covered.

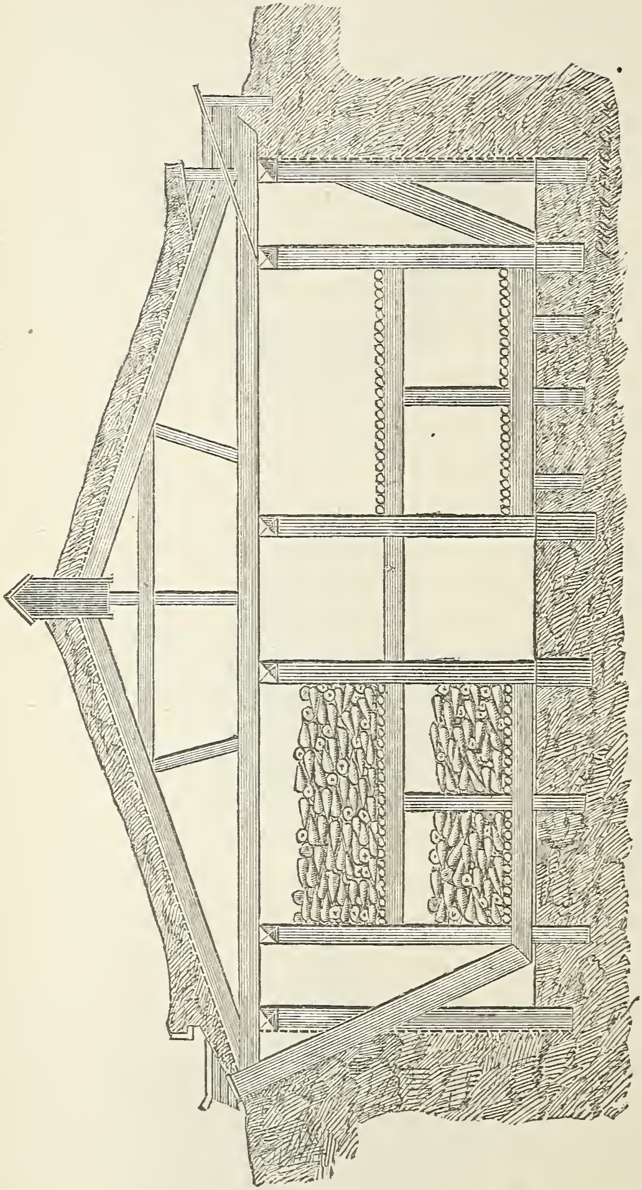

FIG. 35.—Preserving collar (Wahlkoff). Russian plan, vertical section.

SOIL.

As has been indicated already, the character of the soil for the production of beets should be determined by actual trial. No definite rule can be given in regard to a soil from its chemical composition alone. In general it may be said that any soil which will give good crops of the cereals and other farm products will produce good sugar-beets. A sandy loam with a clay subsoil is sometimes recommended as the best for sugar-beets. In California the deposits of the coast valleys which are alluvial or lacustrine in nature have been found to produce a sugar-beet of remarkable richness. The sandy loams of the Platte Valley in Nebraska have also been found to produce a rich beet. I do not know that any scientific trials have been made in the growth of the sugar-beet on the black prairie soils so common in the prairie regions of Indiana, Illinois, and Iowa. It seems to me reasonable to suppose that these soils, after they have been cultivated for a few years in other crops, might in many localities produce a sugar-beet of high quality. The black color of the soils allows them to become most easily warmed by the early suns of spring and would tend to give an impetus to the growth of the beet which would help to carry it through in all the vicissitudes of climate which it might subsequently meet. There are many of these prairie soils which are not only dark in color but are of a loamy nature in texture and capable of being easily worked to a considerable depth. Soils which have been in cultivation for a few years are better suited for the production of the sugar-beet than virgin soils containing large amounts of organic nitrogen. All soils devoted to sugar-beet culture should have good natural drainage or else be artificially drained, so that the tap root of the beet may not reach the water-line of the soil. Very thin soils, or those which reach a hard clay subsoil at a small depth, are not suitable to beet culture, on account of affording no facilities for the penetration of the tap root. Beets grown in such soils are likely to protrude above ground and thus lose a large part of their sugar-storing room. Any soil, selected for the purpose, should have a tillable depth of from 12 to 15 inches, should be well drained, mellow in texture, not becoming hard and impacted after rains, and lending itself easily to tillage.

It is not necessary, in this place, to give many chemical analyses of soils which are found suitable to beet culture since these analyses differ very little from those of soils suitable for other crops. In general, it may be stated that the chemical analysis of a soil suitable to the growth of beets must show the ordinary percentages of the mineral substances necessary to plant growth, viz, phosphoric acid, potash, and lime. Other mineral substances which enter in minute quantities into beets are always found in sufficient quantities in all soils except those of an extremely sandy nature. The presence of a considerable quantity of carbonate of lime is highly essential in soils growing sugar-beets, not only on account of the part it takes in supplying plant nutriment but because of its tendency to prevent the soil from becoming sour by neutralizing any acids which may be found therein, and further from the well-known effect of lime in producing flocculence of the soil which renders it difficult to impact and makes it more easily tillable. The presence of a large amount of carbonate of lime in a soil makes it porous and easily penetrated, both by the rootlets of the plant and by capillary moisture. This condition of the soil tends both to free it easily from water during times of excessive rains and to supply it with moisture in seasons of drouth. It may be well to add also that the field in which the beets are planted should be one freely exposed to the light and air, not shaded by surrounding forests nor lying in a position where its natural inclination will protect it from the rays of the sun. The importance of sunlight in the production of sugar in the beet will be mentioned in another place.

Stammer makes the following statements respecting the soil:*

"It may not be absolutely reliable to say that a soil, because of given chemical and physical properties, is perfectly adapted to the growth of beets; nevertheless, it is in general safe to accept that a soil which is of a porous nature, deep in staple, rich in humus, and more disposed to a loam or calcareous, than to a sand character, is very suitable for the cultivation of the beet, and especially if the subsoil drains off the water freely and the surface of the ground lies well towards the sun. Of course, it is included that not any of the chemical elements, such as potassium or phosphorus, which the beet is in great request of, are meagerly present in the soil.

"The lime content of the soil is most important to the beet, and soils which appear to contain but little of that compound in a free state, which is indicated by the absence of the CO_2 generation when treated with hydrochloric acid, should be well limed for the growing of beets. The action of lime upon clay soils and such as are of a sour nature, is improving physically as well as chemically by giving a milder tone to their composition and effects.

"It is further essential, or at least advantageous, that a soil for the cultivation of beets should be located at a good altitude in order that it have a free expanse to air and light. This observation has been recently established by Hanamann in his experiences, extending over several years, in growing beets in an experiment garden, the products of the experiment plots being meager and poor in quality in comparison with beets grown in the open field. A series of experiments conducted by him have led to the conclusion that the free and elevated position of the land has a decided influence upon the nature and quality of the

* Stammer, Lehrbuch der Zuckerfabrication, p. 169.

beets; and further, that the size of the beets stands in inverse proportion to their content in sugar and salts, and finally that the fine pulverized condition of the soil exerts a great effect upon the growth of the roots, *i. e.*, upon the yield of the crop.

"With the beet the choice of a suitable soil has its special difficulties, as it grows so deep in the earth, and draws much of its essential nutriment from stratas which enter less into consideration in the question of its adaptability for other crops. The nature of the so-called subsoil is, without doubt, of more decided influence upon the growth of the beet than of most other crops, and for the determination of its quality many of the essential stand-points are lacking. This is also the reason why previous experiments have given so few reliable conclusions upon the action of fertilizers. The part of the soil is fertilized from which the beet draws its nourishment during a large part of its existence, it is true, but not during the period of sugar formation, and the chemical means (such as the admixture of chloride of soda) which carry the fertilizing materials to the subsoil, are by no means sufficiently certain in their action that immediate results can be expected from experiments with them.

"On the other hand, the subsoil cultivation which brings up the lower layers of soil for the nourishment of the plant, has produced the best and most desired results in beet cultivation, and all the observations upon the influence of the use of the steam plow upon the beet harvest, and they have resulted favorably without exception, lead to the same conclusions.

"Chemical analysis, especially in its present condition, has little value for beet cultivation, in so far as it relates to the composition of soils generally known as loams, and as regards physical properties, actual experiment is the best means to determine whether a soil is adapted to beet culture or not.

"Naturally soils which do not possess the above general characteristics, for example, sandy, wet, stony, etc., are excluded, while, on the contrary, such as are known from their origin to contain an ample supply of the constituents of beet ash may be presumed in all probability to be well adapted to beet culture. Such a conclusion, however, should not be drawn too hastily from a single experiment; the effect of the necessary preparation of the soil makes itself felt but slowly, so that it is brought gradually into proper condition."

THE CLIMATE AND SOILS OF CALIFORNIA IN THEIR RELATIONS TO BEET CULTURE.*

"The soils and climate of California have been carefully studied by Prof. E. W. Hilgard in his report published in Volume VI, Tenth Census, p. 665, *et seq.*

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* Bull. 5 cit. p. 90, *et seq.*

"The following table contains data of thermal observations. It will be seen at once that the summer temperature of the interior valleys of the western or coast division is entirely too high for successful sugar-beet culture.

WESTERN OR COAST DIVISION.

[From vol. vi, Tenth Census, p. 668.]

Station.	County.	Elevation.	Years of observation.	Temperature, Fahrenheit. General average. Summer.	General average. Winter.	General average. Year.	Monthly extremes. Summer. Maximum.	Summer. Year.	Winter. Maximum.	Winter. Year.
Coast region, north.		Feet.		°	°	°	°		°	
Camp Lincoln	Del Norte	......	2	59.5	47.2	53.9	......	......	......	.....
Fort Humboldt	Humboldt	50	16	58.2	47.0	52.9	......	......	......	.....
Camp Wright	Mendocino	......	6	74.7	58.8	57.8	......	......	......	.....
Coast region, middle.										
Napa	Napa	95	5	70.3	49.3	59.9	......	......	......	.....
San Francisco	San Francisco	130	11	58.0	50.1	55.2	....	......	......	.....
Oakland	Alameda	14	5	67.8	52.2	57.7	72.6	1879	49.1	1880
Martinez	Contra Costa	......	4	70.1	48.9	60.3	74.5	1878	41.9	1880
Jan José	Santa Clara	91	7	66.7	49.5	56.8	76.0	1879	42.2	1876
Santa Cruz	Santa Cruz	2,500	4	62.9	50.5	59.2	66.8	1881	46.2	1880
Coast region, south.										
Monterey	Monterey	140	12	59.7	50.2	55.5	......	......	......	.....
Salinas	....do	......	6	60.6	50.8	55.6	65.1	1877	43.9	1882
Soledad (interior)	....do	3,213	6	66.9	48.8	57.8	77.3	1876	41.8	1877
Santa Barbara	Santa Barbara	20	7	67.9	54.1	61.4	70.0	1874, 1876, 1877	50.4	1875
Los Angeles	Los Angeles	265	7	73.2	55.6	64.9	83.3	1876	49.9	1882
Interior valley.										
Riverside (Rio de Jurupa)	San Bernardino	1,000	1½	74.2	53.2	63.7	......	......	......	....
Colton	....do	965	4	80.1	50.2	65.1	86.1	1879	44.9	1882
San Diego	San Diego	64	20	69.7	54.1	62.1	......	......	......	.....

INTERIOR AND EASTERN DIVISION.

Station.	County.	Elevation.	Years of observation.	Temperature, Fahrenheit.						
				General average.			Monthly extremes.			
							Summer.		Winter.	
				Summer.	Winter.	Year.	Maximum.	Year.	Maximum.	Year.
Northern Sierra and Lava Beds.										
		Feet.		°	°	°	°		°	
Fort Jones	Siskiyou	2,570	5	71.1	34.1	52.3	......	......	......	.....
Fort Bidwell	Modoc	4,680	5	71.1	32.3	50.8	......	......	.....	.....
Great Valley (Sacramento division.)										
Redding	Shasta	556	7	81.6	47.3	63.4	87.2	1879	42.5	1880
Red Bluff	Tehama	308	10	80.8	47.5	63.7	88.9	1875	39.9	1879
Marysville	Yuba	67	10	78.7	49.5	64.4	83.9	1871	44.4	1880
Sacramento	Sacramento	30	10	71.8	48.2	60.8	76.9	1876	43.0	1880
Foot-hills of the Sierra.										
Auburn	Placer	1,360	11	74.1	45.4	58.6	80.5	1875	39.8	1882
High Sierra.										
Cisco	Placer									
Truckee	Nevada	5,934	11	60.9	32.7	45.2	73.1	1871	26.3	1880
		5,819	11	61.1	27.7	43.3	70.3	1871	21.7	1874 1880
Great Valley (San Joaquin division).										
Stockton	San Joaquin	23	10	72.5	48.2	60.8	77.7	1872 1874	44.0	1879
Modesto	Stanislaus	91	8	78.2	47.8	63.2	85.3	1879	40.4	1881
Merced	Merced	171	9	79.1	49.0	63.4	85.1	1874	43.2	1876
Fresno	Fresno	292	5	84.1	51.3	67.6	90.0	1878	43.9	1882
Tulare	Tulare	282	6	83.8	45.9	64.4	95.2	1874	39.1	1874
Sumner	Kern	415	7	86.2	48.7	67.3	93.0	1875	41.9	1878

" Following is Professor Hilgard's description of the climate of California :

As to the change in temperature in ascending the Sierra from the valley, the following statement is made by Mr. B. B. Redding in a paper read before the California Academy of Sciences in 1878 .

" It has been found that the foot-hills of the Sierra up to the height of about 2,500 feet have approximately the same temperature as places in the valley lying in the same latitude. It has also been found that with the increased elevation there is an increase of rain-fall over those places in the valley having the same latitude, as, for instance, Sacramento, with an elevation above the sea of 30 feet, has an annual mean temperature of 60.5°, and an average rain-fall of 18.8 inches, while Colfax, with an elevation of 2,421 feet, has an annual mean temperature of 60.1° and an annual rain-fall of 42.7 inches. This uniformity of temperature and increase of rain-fall appears to be the law throughout the whole extent of the foot-hills of the Sierra, with this variation as relates to temperature, viz, that as the latitude decreases the temperature of the valley is continued to a greater elevation. To illustrate, approximately, if the temperature of Redding, at the northern end of the valley, is continued to the height of 2,000 feet, then the temperature of Sacramento, in the center of the valley, would be continued up to 2,500 feet, and that of Sumner, at the extreme southern end of the valley, to 3,000 feet."

"It is curious to note that, as appears from Mr. Redding's statement, the lowest temperature thus far observed at the two opposite ends of the valley, Redding and Sumner, are the same, viz, 27°.

"It will be noted that in the southern region the difference between the summer means or between winter means, as well as between the annual means, is quite small when Santa Barbara and San Diego, both lying immediately on the coast, are compared. At Los Angeles, 20 miles inland, all these means are notably higher; still farther inland, and with increasing elevation, the summer mean rises, while the winter mean falls at Riverside, as well as more strikingly at Colton, although at the latter point the annual mean is almost the same as at Los Angeles.

"To convey an easily intelligible idea of some of the climatic differ ences indicated in the table, it may be stated that while in the great valley a few inches of snow cover the ground for a short time nearly every winter as far south as Sacramento, and snow flurries are occasionally seen even at the upper end of the San Joaquin Valley, snow has fallen in the streets of San Francisco only once since the American occupation to such a depth as to allow of snowballing (which during a few hours created a state of anarchy, and only a few times has enough fallen to whiten the ground for a few minutes or hours. Hence the heliotrope, fuschia, calla lily, and similar plants endure year after year in the open air, while at a corresponding latitude in the interior they require some winter protection. Lemon and orange trees never suffer from frost on the bay, but their fruit also rarely ripens save in favored localities. In the interior these trees more frequently suffer from frost, but the high summer temperature matures the fruit some weeks earlier than even in the southern coast region. Cotton would, as a rule, be frost-killed in the great valley in November, while on the coast it might endure through several mild winters; but within reach of the summer fogs of the coast it fails to attain a greater height than eight or ten inches the first season, and sometimes can scarcely succeed in coming to bloom before October. Subtropical trees, which in the cotton stages grow rapidly and luxuriantly, such as the crape myrtle, paulownia, catalpa, mimosa (Julibrissin), and others, either grow very slowly or remain mere shrubs in the coast climate, while in the interior they develop as in the Gulf States. The vine flourishes near San Francisco, but fails to mature its fruit, yet it yields abundant and choice crops near San José, where the immediate access of the coast fogs is intercepted by a range of hills. It is thus obvious that, with the varying topography, the change in the direction of a valley or mountain range, the occurrence of a gap or of a high peak in the same permitting or intercepting communication with the coast on the one hand or with the interior on the other, there exists innumerable local climates, 'thermal belts,' sheltered nooks, and exposed locations, each of which has its peculiar adaptations apart from soil, and the recognition and utilization of these adaptations require knowledge and good judgment, and count heavily in the scale for or against success in agriculture in California.

"*Rain-fall.*—As regards the rain-fall, the prominent peculiarity throughout the State is the practically rainless summer. While it is true that rain has been known to fall in every month in the year, the average amount of precipitation during the three summer months is less than 1 inch in the greater portion of the States, and less than 2 inches even in the most favored part, viz, the counties just north of San Francisco Bay. Frequently not a drop of rain falls in the interior valley and the southern region from the middle of May to November, and as the agricultural system of California is based upon the expectation of this dry weather, summer rains are not even desired by the farmers at large. Northward, in the mountainous and plateau regions adjoining Oregon, the season of drought becomes shorter, as is also the case in the high Sierras, and thus there is a gradual transition toward the familiar régime of summer rains and occasional thunder-storms which prevail in Oregon and Washington west of the Cascade Range.

"Since the growing season, in the case of unirrigated lands at least, thus practically lies between November and June, and each harvest is essentially governed by the rains occurring within these limits, it is the universal and unconscious practice to count the rain-fall by 'seasons' instead of by calendar years; hence the current estimate of local rain-fall averages in California differs not immaterially from that of the usual meteorological tables, in which the paramount distinction between the *agriculturally* 'dry' and 'wet' seasons is more or less obliterated. The data hereinafter given are therefore, as a rule, 'seasonal' and not 'annual,' and are largely those of the observations conducted along its lines by the Central and Southern Pacific Railroad.

"The mean annual rain-fall of the greater (middle and southern) part of the State is less than 20 inches, the northern limit of that region lying between Sacramento and Marysville, in the great valley; while on the Sierras, the region of rain-fall, between 20 and 26 inches extends as far south as the heads of King's and Kern Rivers, furnishing the waters upon which depends the irrigation of the San Joaquin Valley; thence southward the rain gauge rapidly descends to 8 and 4 inches, and less in the Kern Valley, the Mojave Desert, and the basin of Nevada.

"A rapid decrease of rain-fall is observed in the great interior valley. From 42 inches at Redding, at the northern end of the valley, and 24 inches at Red Bluff, 24 miles to the southward, the annual mean falls to about 19 inches at Sacramento and to 16 at Stockton. Thence southward the rain-fall descends to a mean of only 10 inches at Merced, 7 at Fresno, and 4 at Bakersfield, near the southern end of the San Joaquin Valley, separated only by the Tehachapi Mountains from the western margin of the Mojave Desert, in which the rain-fall is still less.

"Along the coast proper Cape Mendocino bears the reputation of a kind of weather divide. Mariners expect a change of weather whenever they round this cape, and on land it marks the region where the character of vegetation begins to change rapidly from that of southern or middle California toward that of Oregon. At and immediately north of the cape the rain-fall reaches an annual mean of 40 inches. A short distance southward, at Point Arenas, the annual fall is 26 inches, and from 23 to 21 inches in the region of San Francisco; it falls to 16 inches at Monterey and Santa Barbara, 12 at Los Angeles, and 9 at San Diego.

"Northward of Cape Mendocino the rain-fall increases rapidly, rising to over 70 inches in the northwestern corner of the State. Inland from the coast the increase is less rapid, but the rain-fall rises at points in the Shasta region to as much as 108 inches in some years. Southward the region of rain-fall exceeding 20 inches extends in the coast range slightly farther south than in the great valley, so as to include all but the most southerly portions of the counties of Sonoma, Napa, and Marin. Southward of San Francisco again a region of more abundant rain-fall includes the western Santa Clara Valley, Santa Cruz Mountains, Monterey Bay, and the lower Salinas Valley, where from 13 to 16 inches fall annually.

"Ascending the Sierra from the great valley there is a rapid increase of rain-fall, which, from data furnished by the records of the railroad, may be estimated at 1 inch for every 100 to 150 feet of ascent.

"The following tables show more in detail the rain-fall averages for representative points, the data being derived mainly from the observation made under the auspices of the Central and Southern Pacific Railroad and given for 'seasons' reaching from July to June inclusive.

WESTERN OR COAST DIVISION.

Station.	County.	Elevation.	Years of observation.	Average.	Maximum.	Year.	Minimum.	Year.
Coast Range, north.		Feet.		In.	In.		In.	
Camp Lincoln	Del Norte	......	2	73.4	......	....	......	....
Fort Humboldt	Humboldt	50	16	35.9	......	....	......	....
Camp Wright	Mendocino	......	6	43.9	......	....	......	....
Coast Range, middle.								
Napa	Napa	95	5	26.6	34.7	1877-'78	17.1	1881-'82
San Francisco	San Francicso.	130	10	20.7	32.1	1877-'78	8.8	1876-'77
Oakland	Alameda	14	5	20.6	29.3	1877-'78	9.6	1881-'82
Martinez	Contra Costa	......	4	16.1	19.7	1880-'81	12.9	1881-'82
San José	Santa Clara	91	8	11.4	19.3	1877-'78	5.0	1876-'77
Santa Cruz	Santa Cruz	2,500	5	26.4	39.2	1877-'78	22.0	1878-'79
Coast Range, south.								
Monterey	Monterey	140	12	15.7	......	....	......	....
Salinas	do	......	9	12.8	23.7	1877-'78	3.9	1876-'77
Soledad (interior)	do	3,213	8	7.9	15.3	1875-'76	2.7	1876-'77
Santa Barbara	Santa Barbara	20	11	16.2	31.5	1877-'78	4.5	1876-'77
Los Angeles	Los Angeles	265	7	12.0	21.9	1875-'76	4.6	1876-'77
Interior Valley.								
Riverside (R. de Jurupa)	San Bernardino	1,000	1½	13.6	......	....	......	....
Colton	do	965	6	8.2	14.5	1877-'78	5.9	1876'-77
San Diego	San Diego	64	20	9.3	......	....	......	....

INTERIOR AND EASTERN DIVISION.

Station.	County.	Elevation.	Years of observation.	Average.	Maximum.	Year.	Minimum.	Year.
Northern Sierra and Lava Beds.		*Feet.*		*In.*	*In.*		*In.*	
Fort Jones	Siskiyou	2,570	5	21.7	.....	.....	.....	.....
Fort Bidwell	Modoc	4,680	5	20.2	.....	.....	.....	.....
Great Valley (Sacramento Division).								
Redding	Shasta	556	7	42.1	60.0	1877–'78	25.4	1881–'82
Red Bluff	Tehama	308	10	24.0	52.7	1877–'78	13.6	1874–'75
Marysville	Yuba	67	11	17.8	26.9	1873–'74	12.2	1876–'77
Sacramento	Sacramento	30	32	18.7	25.5	1875–'76	9.2	1876–'77
Foot-hills of the Sierra								
Auburn	Placer	1,360	11	34.0	44.3	1875–'76	18.9	1876–'77
High Sierra.								
Cisco	Placer	5,934	11	60.8	82.7	1880–'81	34.1	1876–'77
Truckee	Nevada	5,819	11	34.1	44.0	1871–'72	18.0	1876–'77
Great Valley (San Joaquin Division).								
Stockton	San Joaquin	23	32	15.8	20.6	1871–'72	7.2	1876–'77
Modesto	Stanislaus	91	11	9.6	13.4	1875–'76	4.3	1876–'77
Merced	Merced	171	10	9.7	12.7	1875–'76	3.2	1876–'77
Fresno	Fresno	292	5	7.0	8.9	1877–'78	4.9	1878–'79
Tulare	Tulare	282	8	6.2	10.0	1880–'81	3.1	1878–'79
Sumner	Kern	415	7	4.2	8.0	1877–'78	1.3	1878–'79

"Were the rainfalls of 20 inches and less distributed over the whole or even the greater part of an ordinary season of the temperate zone, it would be altogether inadequate for the growing of cereal or other usual crops of that zone; but since in California nearly the whole of it usually falls within six months (November and April inclusive), and by far the greater part within the three winter months, during which a 'growing temperature' for all the hardier crops commonly prevails, it becomes perfectly feasible to mature grain and other field crops before the setting in of the rainless summer, provided only that the aggregate of moisture has been adequate and its distribution reasonably favorable. The grain sown into the dust of a summer-fallowed field begins to sprout with the first rain, and thenceforward grows more or less slowly, but continuously, through the winter. It is ready to head at the first setting in of warm weather, from the end of March to May, according to latitude, and becomes ready for the reaper from the end of May to the end of June. Once harvested, the grain may be left in the field for several months, thrashed or unthrashed, without fear of rain or thunder storms. As a matter of course, the grain-grower may also, at his option, sow his grain at any time after the beginning of the rains, and good crops are sometimes obtained from sowings made late in February. Usually, however, the late-sown grain is cut for hay when in the milk, in April and May, for, since meadows can form no part of the agricultural system, except where irrigation is feasible, the hay grasses commonly grown in the Eastern States are available only to a limited extent, and wheat, barley, and oats take their place. Again, there is no strict distinction or limit between fall and spring grain, since the sowing season extends from October to February, Thus the winter months are a very busy season for the farmer in California, as he has to watch his opportunity for putting in his crops between rains. The time between lying-by and harvest is nearly filled up by gardening and haying operations. The latter are occasionally interrupted by one or two light showers, rarely enough to injure the quality of the hay. Protracted rainy spells or thunder-storms, calling for hasty gathering of the cut grain into shocks, are unknown in harvest time, as are also sprouted or spoiled grain, except when the sacked grain is left out in the fields so late as to catch the first autumn rains. It will thus be seen that midsummer finds the California grain-grower comparatively at leisure.

"But while the culture of hardy plants of rapid development was the first and most obvious expedient resorted to by the American settlers, in order to utilize the fertile soils of the region of rainless summers, that of selecting culture plants adapted to arid climates was the one naturally suggesting itself to the missionary padres, who brought with them from the Mediterranean region of Europe the vine, the fig, the olive, the citrus fruits, as well as from adjacent portions of Mexico the culture of cotton, to which, however, but little attention was given by them, the growing of wool being better adapted to the temper of their native laborers. And as they relied largely on irrigation for the success of their annual crops, it was only in very extreme cases that a deficient rain-fall so affected their interests as to give the fact a place in their records.

"*Variation and periodicity of rain-fall.*—While the means of rain-fall given above will not vary widely when any large numbers of years are taken together, the variations from one year to another are often sufficiently great to tempt many to invest heavily in putting in crops on the chances of a favorable season, which would bring a fortune at one venture, but sometimes results in a total loss and consequent ruin to investor. Such cases of agricultural gambling were at one time not uncommon in the San Joaquin Valley especially, the turning point of profit or loss being a single light shower at the critical time or the occurrence of a norther for a day or two. More ingenuity has been spent in trying to forecast the weather for the season in time to determine the chances of success, but it will generally be found that the oldest citizen, if he is candid, will be far more reserved in his opinions than later comers.

"However steady and reliable the summer climate may be, that of a California winter is most difficult to forecast from day to day and from week to week, and while there are certain rules that are ordinarily counted upon, the cases where 'all signs fail' are very frequent, and surprises are abundant. A discussion of the observations made from

1849 to 1877, by Dr. G. F. Becker, late of the University of California, and now of the United States Geological Survey, seems to indicate as probable a cycle of thirteens years between extreme minima of drought years, and some data I have since obtained from the records of the missions seem to confirm still further this conclusion. The first minimum within the time of the American occupation of California occurred in the season of 1850–'51, when the rain-fall at San Francisco was 10.1 inches, and the third was the season of 1876–'77, with 10 inches. The next succeeding season of minimum would be that of 1889–'90.

Number.	Soil title.	Locality.	Depth.	Vegetation.	Insoluble residue.
	COAST RANGE REGION.				
	South of San Pablo Bay.				
168	Valley soil	Santa Paula, Ventura County	12		85.664
182	Reddish mountain soil	do	12	Grass, herbs	74.930
170	Bench-land subsoil	Hollister's ranch, Santa Barbara County.	12-18	Oaks	83.065
600	Upland soil	Poverty Hill, San Benito County	12	Cultivated 12 years	85.596
606	Upland loam soil	Soquel ranch, Santa Cruz County	12	Cultivated	80.426
702	Chaparral soil	Two miles northeast of Saratoga, Santa Clara County.	12		57.449
37	Valley soil	Pescadero, San Mateo County	....	Redwood, pine, oak, alder, buckeye, and madrone.	78.084
680	Sandstone soil	San Francisco, San Francisco County.	8	Scrubby live-oak	78.135
682	Sandstone subsoil	do	8-18		70.224
643	Black waxy adobe soil	Cobton ranch, Contra Costa County.	12	Sunflower	50.960
692	Dark soil, rolling uplands.	Livermore Valley, Alameda County	6	Scattering white oak and poison-oak.	80.262
693	Dark subsoil, rolling uplands.	do	6-18	do	80.658
694	Red gravelly soil, rolling uplands.	do	8	do	81.941
649	Sediment soil	Arroyo del Valley, Livermore Valley, Alameda County.	....	Shrubs, herbs, and some sycamore.	71.156
1	Black adobe soil	University grounds, Alameda County.	12-22	Live-oaks, large	....
2	Subsoil No. 1	do	22-30	do	......
4	Adobe ridge subsoil	do	10-20	Scattered live-oak, small.	......
	North of San Pablo Bay.				
185	Valley soil	G. F. Hooper's vineyard, Sonoma County.	12	Oaks and gape-vines.	76.089
188	Red mountain soil	do	12	Oaks, manzanita chaparral.	34.392
207	Eel River bottom soil	Three miles east of Ferndale, Humboldt County.	12		65.346
205	Subsoil of No. 207	do	12-25		69.373
676	Red volcanic soil	Flat on Clear Lake, Lake County	12	Not known	49.604
672	Gray valley soil	Two miles south of St. Helena, Napa County.	12	Large white oak	77.017

subsoils. [Vol. vi. Tenth Census, p. 738.]

Silica soluble in Na_2CO_3.	Total insoluble residue and silica.	Potash.	Soda.	Lime.	Magnesia.	Brown oxide of manganese.	Ferric oxide.	Alumina.	Phosphoric acid.	Sulphuric acid.	Carbonic acid.	Water and organic matter.	Total.	Hygroscopic moisture.	Temperature of absorption ° C.	Analyst.
1. 847	87. 511	0. 634	0. 070	0. 759	0. 593	0. 025	3. 350	3. 099	0. 200	0. 003	......	3. 132	99. 372	5. 49	15. 0	Jappa.
7. 912	82. 842	0. 621	0. 164	0. 952	0. 955	0. 036	5. 070	5. 936	0. 127	0. 039	......	2. 669	99. 414	6. 59	15. 0	Do.
4. 678	87. 743	0. 506	0. 058	0. 561	0. 666	0. 055	3. 116	2. 995	0. 223	0. 094	......	3. 854	99. 871	5. 98	15. 0	Do.
2. 567	88. 163	0. 333	0. 109	0. 676	0. 526	0. 048	2. 856	4. 214	0. 027	0. 015	......	3. 476	100. 443	5. 22	12. 5	Do.
3. 028	83. 454	0. 343	0. 126	0. 502	0. 390	0. 014	3. 928	5. 711	0. 053	0. 009	.....	4. 955	99. 485	5. 60	15. 0	Do.
5. 114	62. 563	0. 859	0. 260	1. 987	2. 428	0. 098	10. 019	9. 516	0. 139	0. 063	......	11. 921	99. 853	12. 09	15. 0	Do.
3. 237	81. 321	0. 541	0. 231	0. 925	0. 820	0. 039	4. 934	4. 821	0. 084	0. 027	......	6. 757	100. 500	7. 38	15. 0	Do.
3. 458	81. 593	0. 675	0. 080	0. 846	0. 788	0. 053	5. 682	5. 162	0. 031	0. 053	......	5. 404	100. 359	6. 02	15. 0	Morse.
5. 532	75. 756	0. 590	0. 172	0. 399	1. 221	0. 059	7. 268	9. 737	0. 011	0. 022	......	4. 900	100. 135	9. 41	15. 0	Do.
9. 020	59. 980	0. 192	0. 741	2. 471	0. 890	0. 065	11. 090	15. 689	0. 057	0. 045	Trace	8. 304	99. 524	13. 51	15. 0	Do.
5. 023	85. 285	0. 299	0. 108	0. 813	0. 647	0. 065	3. 584	4. 933	0. 066	0. 010	......	4. 047	99. 857	5. 67	15. 0	Jappa.
5. 157	85. 815	0. 357	0. 121	0. 693	0. 666	0. 025	3. 647	5. 329	0. 062	0. 008	......	3. 435	100. 158	6. 12	15. 0	Do.
3. 756	85. 697	0. 323	0. 081	0. 720	0. 563	0. 030	3. 620	5. 540	0. 061	0. 008	......	3. 550	100. 193	4. 53	15. 0	Do.
4. 938	76. 094	1. 143	0. 123	2. 049	3. 046	0. 044	5. 648	7. 153	0. 117	0. 101	1. 004	3. 679	100. 201	5. 67	15. 0	Do.
......	77. 844	0. 452	0. 074	1. 050	1. 211	0. 078	4. 675	7. 788	0. 231	0. 077	......	5. 718	99. 198	....	15. 0	Sutton.
.....	69. 563	0. 348	0. 109	0. 998	1. 913	5. 093	7. 208	13. 970	0. 116	0. 028	......	6. 600	100. 946	.....	....	Do.
......	86. 002	0. 189	0 154	0. 484	0. 452	0. 038	4. 013	5. 532	0. 057	0. 021	.....	4. 051	100. 993	....	....	Do.
6. 839	82. 928	0. 435	0. 123	0. 744	0. 578	0. 025	5. 793	5. 092	0. 187	0. 171	......	3. 715	99. 791	4. 98	15. 0	Jappa.
14. 110	48. 502	0. 319	0. 058	0. 670	0. 712	0. 146	25. 955	12. 160	0. 166	0. 274	......	11. 640	100. 602	13. 71	15. 0	Do.
6. 896	72. 242	1. 127	0. 282	0. 105	3. 329	0. 117	6. 986	10. 236	0. 167	0. 020	......	5. 629	100. 240	7. 87	15. 0	Do.
3. 588	72. 961	1. 134	0. 120	0. 101	3. 239	0. 054	7. 307	9. 758	0. 141	0. 026	......	4. 665	99. 506	6. 21	15. 0	Do.
5. 934	55. 538	0. 452	0. 170	0. 658	0. 610	0. 051	10. 477	22. 585	0. 031	0. 033	......	9. 654	100. 259	11. 11	15. 0	Morse.
3. 340	80. 357	0. 746	0. 477	0. 600	1. 331	0. 041	5. 656	5. 671	0. 101	0. 050	......	5. 252	100. 282	4. 50	15. 0	Do.

Soils of the southern region.

Constituents.	Los Angeles County.			San Diego County.	
	Soil of San Gabriel Valley.	Pomona Colony. Low mesa soil.	Pomona Colony. Subsoil.	Soil of mesa land.	Bottom soil Colorado River.
	No. 130.	No. 382.	No. 381.	No. 48.	No. 506.
Insoluble matter	81.12	72.519 } 77.640	75.304 } 79.176	86.21	58.574 } 63.901
Soluble silica		5.121	3.872		5.327
Potash	0.21	0.839	0.962	0.48	1.177
Soda	0.17	0.296	0.301	0.14	0.162
Lime	0.68	2.354	2.052	0.36	8.671
Magnesia	1.77	2.225	2.154	0.54	2.966
Brown oxide of manganese	0.10	0.039	0.043	0.10	0.025
Peroxide of iron	6.30	8.097	7.342	3.69	4.139
Alumina	6.79	5.974	5.835	5.12	8.379
Phosphoric acid	0.16	0.018	0.049	0.23	0.133
Sulphuric acid	0.07	0.022	0.020	0.03	0.145
Carbonic acid	....	....	....	....	7.818
Water and organic matter	3 07	2.550	2.546	2.60	3.344
Total	100.50	100.054	100.480	99.50	100.860
Humus	....	0.324	....	0.555	0.752
Available inorganic	....	0.263	....	1.439	1.151
Available phosphoric acid	....	....	....	....	0.133
Hygroscopic moisture	2.30	3.460	2.370	2.340	9.204
Absorbed at	15° C.	15° C.	15° C.	15° C.	15° C.

"There are many parts of the 'valleys of the Coast Range' where the soil is suitable for beet culture. The following table gives the areas of this soil in regions where the climate will permit beet culture. The areas for each county are as follows:

"*The area of soil suitable for beet cultivation, by counties.*

	Square miles
Los Angeles	1,480
San Bernardino	465
San Mateo	50
Contra Costa	70
Alameda	225
Santa Clara	405
Monterey	700
San Benito	115
San Luis Obispo	1,090
Santa Barbara	300
Ventura	170
Sonoma	350
Napa	145
Other valleys	40
Lake	100
Mendocino	125
Sum	5,830

"This gives a total area in acres of 3,731,200. Granting that two thirds of this area are unfit for beet culture for lack of moisture and local causes, there remains over a million and a quarter acres on which beets could be grown. Of this area not less than half a million acres could be cultivated annually. From the data of yield of beets per acre and sugar per ton of beets, already given, the average may be put at 15 tons and 9 per cent., respectively, or 2,700 pounds of sugar per acre. For 500,000 acres this would give 1,250,000,000 pounds.

THE SUGAR-BEET IN OREGON AND WASHINGTON TERRITORY.

"I was anxious to extend my investigations of the possibilities of beet culture into Oregon and Washington Territory, but the limited time at my command prevented this design from being carried into execution.

"Having learned that Mr. E. Meeker, of Puyallup, Wash., had been engaged in the cultivation of beets, I addressed him a letter making inquiries concerning the matter.

"In answer I received the following communication. I regret to say the samples of beets which Mr. Meeker hoped to be able to forward for analysis have not been received.

"Mr. Meeker says:

"I am in receipt of your favor of 21st ultimo from San Francisco, and herewith inclose an article to answer your question with reference to growing sugar-beets in Oregon and Washington.

"I will send you samples of beets grown by myself, and from others if I can obtain them. T. M. Alvord, White River, Wash., takes great interest in this question; also J. W. Sprague, Tacoma, Wash., and James McNaught, Seattle, Wash. I would also suggest to send to the secretaries of the chambers of commerce of both Seattle and Tacoma.

"I send you paper containing an article of mine giving the cost in detail of our present year's crop.

"My article refers only to Puget Sound country, or what is here known as western Washington. I am not fully advised as to the valley lands of Oregon, but I think their heavy clay wheat-lands unsuitable. I also think the prairie, or in fact any lands of eastern Oregon or Washington, are unsuited from the excess of alkali contained in the soil, also from scarcity of fuel.

"The climate of western Washington is mild and equable, neither very cold in winter nor hot in summer, and seems to be exactly suited to growing the sugar-beets to perfection.

"There is always an abundant rain-fall in summer, so that we never have a failure of crops; the autumns are free from heavy frosts or freezing weather (at this writing, December 1, there has as yet been no freezing weather), but usually there is considerable rain.

"We do not irrigate; in fact the soil is loose andfavorable, so that our crops grow well the whole season, and remain green even during a 'dry spell,' which, however, seldom occurs of sufficient duration to endanger crops. The growing season is very long, and all hardy vegetables are produced in great abundance and perfection.

"Soil suitable for producing the sugar-beet is in the alluvial bottoms adjacent to various rivers flowing from the Cascade range of mountains towards salt water.

"These rivers are not large nor the valleys wide, but are numerous; in the Puget Sound Basin there are eleven or more situated north of the Columbia River and south of our northern boundary. I should say the area of land in each of these valleys suitable for beet-culture would average sixty sections of land, or say about 40,000 acres each. This is nearly all timber land and requires clearing, is a deep alluvial sandy loam, very rich, and produces an abundant and certain crop.

"Fuel is abundant, and is widely distributed. The coal is under the table-land or foot-hills of the Cascade range of mountains, and is reached by short lines of railroads. The aggregate monthly output of the mines opened is, I think, about 30,000 tons. It can be increased indefinitely, as the coal area is large, the veins numerous and heavy (thick).

"So far, our sugar-beets have been not only rich but also singularly pure. This is probably to be accounted for from our heavy rain-fall and agreeable climate. The actual cost of raising per ton for a period of five years has been less than $2.50 per ton, and the present year $2.25 per ton. We have grown them for cattle, and could utilize the pulp to great advantage in stall-feeding beef.

"Our winters will admit of working sugar-beets nearly the whole time, the weather seldom being cold enough to interfere with harvesting the beets. Locations can be had where transportation is cheap, where fuel is cheap, where land is cheap, and where the market for sugar is good. It would seem to be difficult to find better conditions for the successful inauguration of this business than here exist, and we firmly rest in the conviction that sooner or later the capital will be found to develop these favorable conditions, and that the day is not far distant when we shall see numerous beet-sugar factories producing not only enough for the immediate home consumption, but also for the great interior country of this continent.

"Following are the results of culture mentioned in the foregoing letter:

"I raised the present year 65 tons of beautiful sugar beets from 2 acres of land. There was no guess work; it was 65 tons of 2,240 pounds from the two measured acres. These cost me $2.25 per ton, and I will give this in detail that your farmers may ponder this question and see that I do not understate the cost:

Plowing and subsoiling two acres	$20.00
Harrowing and clod mashing	6.00
Rolling	4.00
Planting	2.00
Seed	4.00
Cultivating (machine work)	16.25
Hand weeding	20.00
Harvesting	21.50
Housing, 50 cents per ton	32.50
Rent of land	20.00
Total	146.25

"My neighbor, Mr. T. M. Alvord, of White River, has for five years raised an average of 100 tons a year at an average cost of less than $2.50 per ton and an average yield of 20 tons per acre. We *know* that the beets can be raised; that the crop is certain; that the quality is good, pure, rich—in a word, everything desired to make this industry profitable, and now shall we throw this opportunity away, encourage the importation of foreign sugar made by cheap, servile labor, or shall we encourage home production and all the benefits that follow?"

"The following account of the topography, climate, and soils of the Chehalis Valley is taken from an article printed in Gray's Harbor News, Chehalis County, Wash., April 19, 1884:

"TOPOGRAPHICAL FEATURES.

"Western Washington is a name given to that portion of country lying between the Pacific Ocean and the Cascade Mountains, the Columbia River and British America. On its eastern border the Cascade Range, an unbroken chain containing the highest peaks in the United States, stands like a lofty wall, shutting out and hiding the beautiful and fertile country west from the rest of the world. West of this lofty range lies a strip of country about one-half the size of the State of New York, about 110 miles wide and from 200 to 250 miles long. In the southwestern portion of this country, lying near the Pacific and jutting close upon the Columbia River, is a cluster of high hills, and in the northwestern portion, on the peninsula formed by Puget Sound and the Pacific, is the Olympic Mountains, another cluster rising to the height of 8,000 feet. In the north is Puget Sound, perhaps the most beautiful inland sea in the world, with its lofty wooded shores, its innumerable windings and islands, and its deep, clear water. The shores of this sound are high and rocky. But few streams flow into it, and these chiefly on its eastern side. In the southeastern part the Cowlitz River flows along the base of the Cascades in a southerly direction and empties into the Columbia. But in the central part, rising among the hills in the southwestern corner and flowing first east then north, so that the Kalama Branch of the Northern Pacific passes along it, and then west, is a magnificent stream, the Chehalis River, emptying into Gray's Harbor and so into the Pacific Ocean. This is the largest river in Western Washington. It is the only river of any size not subject to summer floods caused by the melting of mountain snows. This river, with its tributaries and including Gray's Harbor, drains a basin of some 3,500 square miles; (the map shows sixty townships, and a greater amount may fairly be reckoned as part of this river valley). As will be seen, Chehalis County is the very heart of western Washington, and it is the heart in a very true sense, in that all that is desirable in western Washington is centered here in its best condition, and here are the means, the forces that are to give life and growth to all the rest.

"CLIMATE.

"From October 13 to November 13, thirteen rainy days, thirteen fair days, and five clear days; from November 13 to December 13, twelve rainy days, thirteen fair, and four rain and shine; from December 13 to January 13, one day snow, six rain, three rain and shine, fourteen fair, and eight clear days; from January 13 to February 13, three days snow, four rain, two rain and shine, ten fair, and twelve clear days; from February 13 to March 13, five days snow, three rain, one rain and shine, sixteen fair, and four clear days; total for the winter, nine days of snow, thirty-eight rain, ten rain and shine, sixty-six fair, and thirty clear days. Days are called clear when not a cloud appears. During this time the range of the thermometer was: First month—lowest 40°, highest 65°, and the average $53\frac{1}{2}$; second month—lowest 34°, highest 55°, average $41\frac{5}{8}$°; third month—lowest 28°, highest 50°, average $37\frac{1}{2}$°; fourth month—lowest 9°, highest 45°, average $23\frac{1}{6}$°; fifth month—lowest 27°, highest 42°, average $36\frac{3}{8}$°. The record of 9° above was the lowest point reached during the last seven years. There was one fall of snow that reached a depth of 6 inches. The record of lowest thermometer for the last seven years is: For 1876–'77, 22°; for 1877–'78, 20°; for 1878–'79, 10°; for 1879–'80, 10°; for 1880–'81, 28°; 1881–'82, 20°; 1883, 9°.

"THE SOIL.

"The soil of the uplands, or hills, is loamy, in places gravelly. It is quick, warm but not strong land as a rule. In some localities where upland clearings have been made reports are given of large crops. It is better adapted to fruit and general gardening. Some of the hills are doubtless good land. It all grades off into bottomland. It is difficult to clear for the immense growth of timber. But in this climate most of these hills will be profitably farmed. Indeed, almost anywhere clover and timothy grass will flourish luxuriantly. But it is the *bottom-land* that is chiefly valuable at present for farming. Thus far the most part is easily cleared, and is as good land as can be found anywhere. It will produce good crops of almost anything, and its fertility is inexhaustible. One piece that has been cultivated almost continuously for twenty years, with no manuring, is to-day as rich as when first plowed. This land is all made land. It is a mixture of alluvial wash and vegetable and animal matter. It is more like garden than field land. A few acres will yield more than a quarter section of much of the land East.

"The bottom-lands in general are subject to winter overflow, though some of them rarely, if ever, are covered. They are apt to be broken by channels which this overflow has made and by sloughs and streams which flow through.

"There is much of this bottom-land. Along each of the principal streams there are wide stretches of it, and along in each stream in this whole Chehalis country there is more or less. But as there are few quarter-sections across which some stream does not flow, so there are few which do not possess some of this bottom-land.

"These bottom-lands that lie down toward the sea are subject to periodical overflow by the tide, and there is a large amount of this about Gray's Harbor and the streams that empty into it. These are in places largely open and covered with a rank growth of wild grass. They are used now principally for pasture. But a dike from 1 to 3 feet high would keep out this tide, and when so diked they are equal to the best of bottom-land. No better land can be found.

"In view of the preceding description I am inclined to believe that in Washington and Oregon soil and climate are very favorable to the growth of a sugar beet of high saccharine strength.

"The mildness of the winter is, though to a less degree than in California, favorable to the season of manufacture. With a wise and careful encouragement of the industry I have no hesitation in saying that the prospects for the development of an indigenous sugar industry in the extreme northwestern part of our country are decidedly bright. It is a field worthy the attention both of experimenters and capitalists."

SOIL AND CLIMATE IN BOHEMIA.

In respect of the soil in Bohemia best suited to the sugar-beet, John B. Howes, commercial agent, makes the following observations:*

"The best soil for quality, as well as quantity of production, according to the experiments of Orth, are those that consist of mild, moist loam about 50 centimeters deep, then loam or marl 1 to 2 meters, and under this sand. Such soils, which are easy to cultivate, have a high degree of absorption, can combine nourishments, and give the plant physically a good start. Such soils are called 'natural sugar-beet soils.'

"It is possible to raise beets on soils that do not have all these qualities, but the crop will be the better the nearer this standard is approached.

"The conditions required for a good sugar-beet soil are—

"(1) Depth, because the roots mostly take their nourishment from a depth of 30 centimeters, and the soil must therefore be loosened and contain nourishment up to this depth.

"(2) Porousness of the subsoil, because it is impossible to cultivate a damp, cold soil at the right time. Such a soil will become cracked if very dry, and the young plants suffer, while the beets will contain little sugar. In such a case drainage must be employed. Clay soils can be

*Report to State Department, page 242.

improved by manuring, by the use of lime, and drainage; light soils by manuring and loamy marl.

"Leplay found that the heaviest beets will be raised in descendant succession, from clay, lime, loam, and sand soils; beets with the greatest percentage of sugar in lime, clay, sand, and loam soils; the most leaves in sand, clay, lime, and loam soils. According to experiments of Marek, the more moisture in the soil the greater will be the development of leaves. This influence is stronger in sand soil than in one of clay. The normal development of the root depends upon organic matter in the soil. The more moistuie there is in the soil the looser the texture, the poorer the quality, and the less sugar will be in the beet.

"The following soils are adapted for the culture of the beet, if they have a good subsoil: Loamy soils, mild, clayey, or sandy, and clay marl. Of clay soils, the mild and loamy ones; if the amount of clay is excessive, the soil must be made suitable by manuring. Strong clay soils are useless for beets, but clay marl soils are good. Sandy soils are least adapted to the cultivation of the sugar-beet, with the exception of loamy sand soil not deficient in humidity and the subsoil possessing enough water-holding power. Lime soils are, with the exception of loamy lime soil, not good for beets. From moist soils are raised good quantities, but poor qualities.

"The best locations for sugar-beet planting are on level or only slightly sloping lands, because work is done best on such lands, and it is impossible for the beets to be swept away by heavy rains."

In regard to climate, Agent Howes has collected the following data (*op. cit.* p. 242):

"In Europe the sugar-beet is successfully planted between the forty-seventh and fifty-fourth degrees of northern latitude; in Germany, between the fifty-first and fifty-fourth; in France, between the forty-seventh and fiftieth; in Austria-Hungary, between the forty-eighth and fiftieth; and in Russia, between the forty-eighth and fifty-third degrees.

"Like all plants, the sugar-beet requires certain conditions of climate to arrive at perfection.

"According to the experiments of Briem, director of the experimental station in Grussbach, Moravia, concerning the distribution of warmth and rain-fall during the period of vegetation of the sugar-beet in the first period, *i. e.*, in the first two months, the time of germinating, the daily temperature was 10.70° C.; in the second period (the time of the development of the vegetative organs), 18.8° C.; and in the third period (in which the storage of the reserve substances takes place), 16.5° C.; and during the whole vegetation, 15.3° C.

"The total warmth in the first period was 650° C.; in the second, 1,150° C.; and in the third, 1,000° C.

"The rain-fall was in the first period 97 millimeters; in the second, 114 millimeters; and in the third, 100 millimeters—together 311 millimeters.

"The sugar-beet needs much warmth and light, sunny days, and a certain amount of moisture.

"The best climate for sugar-beets is the so-called 'wine climate,' with a temperature from 9° to 10° C. in April and May, 17° to 18° C. in June and July, and 15° and 12° in August and September, respectively.

"The sea-coast is not warm enough and has not enough sunny days in June and July to be successful for sugar-beet raising.

"For the first period of vegetation it is necessary that a certain amount of winter moisture be in the ground, as the seeds need moisture to germinate. In the second period warmth and moisture is required for the production of roots and leaves. In the third period, in which the saccharification goes on, dry warmth. If the days be sunny, the beets will become rich in sugar; but if this period be wet, the crop will be great in quantity, but poor in quality. If, after a dry summer, a warm and rainy fall follows, new leaves spring up at the cost of the sugar."

The following observations on soil, culture, and fertilization will be found interesting in connection with the foregoing discussion.*

"The cultural conditions to be regarded as of greatest importance in securing crops of maximum quantity and quality, when a section has been determined upon by a consideration of all other conditions, are choice of soil, etc., its physical character and chemical compositon, and the methods by which these may be modified or improved; the first by the mechanical methods of culture, and the second by the proper and judicious applications of fertilizers. After this will naturally follow the modes of planting and the care to be applied during the season of growth.

"With reference to the choice of soil suited to the culture of the beet-root, opinions seem to differ somewhat, though the principles which appear to govern them tend to the same end. The illustrious Chaptal,† as a result of his study of the plant and its requirements, arrived at the following conclusions:

"Soils which are dry, calcareous, light, etc., are not well suited to the beet.

"Strong clay soils have little aptitude for the culture of this root.

"In order that the root may prosper, it needs, in general, a mellow, fertile soil, the arable stratum of which should be 12 to 15 inches thick.

"The root succeeds more or less well in all arable soils, but the products vary wonderfully according to the nature of the soils.

"Basset ‡ considers that "a fresh soil, rather sandy or silico-calcareous than too calcareous or argillaceous, rich in humus, and deep," should be

* McMurtrie *op. cit.*, pp. 95–117)

† Quoted by Basset in Guide Pratique du Fabricant de Sucre.

‡ Ibid.

chosen. Briem,* in his late work on beet-root culture and sugar manufacture, says, of the physical character of the soil to be chosen, "it should not be too light nor too moist; it should be bare; its subsoil permeable; it should be warm, free from stones, calcareous, and should contain humus." Deherain,† from the results of his experiments and investigations at Grignon, publishes as one of the conclusions arrived at that the nature of the soil does not seem to exercise any sensible action upon the development of the beet, for the same results were obtained in soils consisting of pure silica, of calcareous matter, or of a mixture of calcareous matter and clay.

Vivien‡ found in traveling through the provinces of the Rhine, Hanover, Brandenburg, and Saxony in Germany, that, though in each section there is a wide difference in the nature of the soil, there is a particularly marked homogeneity in the character of the beets.

"Vilmorin considers that any good soil that will grow wheat and corn and has an arable stratum of 12 to 15 inches, will be well suited to this culture; that where chalk exists in large proportion the yield will be small, but the juice pure. All soils should be thoroughly drained, so that the tap root may not find stagnant water in the subsoil.

"Notwithstanding the differing notions expressed above, it will appear that the physical characters of the soil which tend to render it best suited to the cultivation of the beet are porosity of surface and subsoil, to admit of drainage of superfluous water and of free circulation of the air, and power of absorbing and holding in a condition convenient for ready assimilation the elements of plant-food existing within it or coming from external sources. Unless the supply of these elements be continuous and regular, a purely sandy soil would be undesirable. If no means were provided for the removal of surplus water which might be found in a purely clay soil, or to so improve its condition as to admit of free circulation of air as well as water, it is too heavy, and becomes absolutely useless. The same is true of purely calcareous soils, since the same unfavorable conditions would prevail, though perhaps to not quite the same extent. These soils would also be unsuited to the plant itself, because they would not admit of the free progress of the tap root nor of the lateral fibrous roots in their search for nutrition or in following the natural course of development, and, as will appear later on, these conditions have a powerful influence upon the ultimate yield of sugar from the surface cultivated. But if the sandy soil described be mixed with either or both of the others mentioned, and with humus, in suitable proportions, the conditions most favorable to the maintenance of a regular and plentiful supply of food, the healthy condition of the root, and its consequent normal development, will be assured.

* See Critique in Journal des Fabricants de Sucre, 1879.

† Annales Agronomiques.

‡ Journal des Fabricants de Sucre, 1878, 27 March.

"The chemical character of the soil is of quite as great importance as its physical condition. For the proper development of the beet for the production of sugar it should contain in a suitable and assimilable form all the elements usually necessary to the normal existence and development of plants, and attention must therefore be had to the conditions in which these substances exist in the soil. Phosphoric acid, potash, nitrogen compounds, and lime are especially necessary to the life of the plant, but if these exist in insoluble combinations on the one hand, or in forms suitable for assimilation but in excessive quantities on the other, they will either be useless in the economy of nutrition in the first instance, or will stimulate the plant to abnormal growth unsuited to the ready extraction of sugar in the second. It is this branch of the subject that has occupied the attention and enlisted the energies of scientists and landed proprietors, and the influence of the different combinations of the various leading elements of plant-food, and more especially, during later years, of nitrogen in the soil, has constituted the subject of frequent and continued investigation.

"Basset* says:

"Soils charged with mineral salts are injurious to the culture of the beet for extraction of sugar, and are only suited to the cultivation of beets for distillation. In fact, we know that the beet easily absorbs saline matters and that the alkaline salts constitute one of the greatest obstacles to sugar extraction.

"New ground, or that lately cleared of forest, should not be applied to the culture of the beet, and it is considered by good authorities to be detrimental to the quality of the crop to make use of lands for this purpose that have not been under continued cultivation at least ten or fifteen years. This insures an almost complete removal of the nitrates and the organic matters containing nitrogen, which are always present in large quantities in new soils, and which it is well known exert an injurious influence upon the quality of the root.

"Basset, in his work,† gives elaborate tables of analyses of soils to show the chemical composition of those most favorable to the culture, but we will here give the more succinct tables of Champion and Pellet,‡ showing the composition of soils from different departments in the north of France in which beet-root culture is most extensively carried on, and and of one from a similar section of Russia. Those numbered 1, 2, 3 yielded beets of fair quality, containing 12 to 14 parts of sugar per 100 of juice, while that numbered 4 gave beets of bad quality. The last, that from Russia, is quoted by Walkhoff as being well suited to beet culture.

*Guide Pratique du Fabricant de Sucre. †Guide Pratique du Fabricant de Sucre.
‡La Bettrave a Sucre, p. 82.

	1. Somme.	2. Nord.		3. Aisne.	4. Somme.	5. Kalinofska soil.
Organic matters	5.600	4.42	4.840	5.70	8.200	6.207
Silica	81.800	....	82.500	79.00	42.000	72.699
Alumina	7.240	....	8.620	8.50	3.91	9.974
Lime	0.570	0.476	0.420	0.25	23.220	1.930
Peroxide of iron	2.880	....	2.180	5.50	2.310	2,834
Phosphoric acid	0.070	0.008	0.077	Trace..	0.385	0.093
Potash	0.064	} 0.130	} 0.140	Trace..	0.044	2.047
Soda	0.085			} 2.85	0.058	0.914
Carbonic acid	0.400	0.600	0.700		19.050	1.280
Other matters	1.351	....	1.523		0.823	2.022
	100.000	1[illegible]0.000	100.000	100.000	100.000	100.000
Total nitrogen	0.088	0.140	0.120	0.154	0.270	0.234
Ammonia	0.013	0.040	0.030	0.016	0.010	....
Sand	72.100	85.000	80.000	62.000	35.770	....
Clay	22.000	9.000	14.000	30.000	10 to 12	....

"The same authors quote Schübler as giving the following as the general composition of good soil for beet culture:

Clay	33.300
Siliceous sand	63.000
Calcareous sand	1.200
Calcareous earth, humus	2.500

"We now come to the study of the means employed to supply the deficiencies of plant-food in the soil, due either to the natural condition or the exhaustion by crops, and the influence of the means employed upon the production of rich and valuable roots.

"The general composition of the beet root and leaves is given by Champion and Pellet, as follows: They state that for rich beets the weight of leaves is about 50 per cent. that of the root, and 25 to 30 per cent. that of roots containing 9 to 11 per cent. of sugar.

"The table shows the general composition of leaves and roots of beets containing 15 per cent. of sugar:

	In roots.	In dry matter.	In leaves.	In dry matter.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Water	74.00	....	83.50	....
Nitrogen	0.40	1.55	0.38	2.30
Ashes	0.80	3.10	4.35	26 20

"For a yield of 20 French tons* of beets and 10 French tons of leaves per acre, there would be removed from the soil:

	Nitrogen.	Total ashes.
	Pounds.	*Pounds.*
20 tons roots	178.1	356.2
10 tons leaves	84.8	934.1

*2,200 pounds.

"Or, for an average richness of 11 per cent. of sugar:

	In roots.	In dry matter.	In leaves.	In dry matter.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Water	82.00	....	84.50	....
Nitrogen	0.25	1.39	0.38	2.45
Ashes	0.95	5.30	3.85	24.8

"Or, for a yield of 20 French tons per acre:

	Total nitrogen.	Total ashes.
	Pounds.	*Pounds.*
20 tons roots	110	418
6 tons leaves	50	508.2

"The composition of the ashes of the leaves and roots referred to 1,000 parts green matter is as follows:

	Beets supposed to contain 10 per cent. sugar.		Beets supposed to contain 15 per cent. sugar.	
	Leaves.	Roots.	Leaves.	Roots.
Potash	9.23	2.93	10.0	2.66
Soda	3.23	0.51	3.47	0.45
Lime	3.50	0.42	3.75	0.38
Magnesia	2.81	0.38	3.03	0.33
Chlorine	3.23	0.57	3.47	0.50
Sulphuric acid	1.50	0.22	1.63	0.19
Silica	0.31	0.34	0.33	0.30
Phosphoric acid	2.23	0.59	2.40	0.51
Undetermined	2.03	0.16	1.92	0.13
Total mineral matters	28.07	6.12	30.0	5.45
Total solids	138.0	167.5	140.0	240.0
Nitrogen	3.3	2.5	3.8	4.0

"From these figures we may easily determine the quantity of the different constituents removed by average crops. Supposing the average to be 20 tons of roots per acre, the consumption of the different constituents would be, for beets of differing richness, as shown in the following table:

	For beets containing 10 per cent. sugar.		Total.	For beets containing 15 per cent. sugar.		Total.
	Six tons leaves.	Twenty tons roots.		Ten tons leaves.	Twenty tons roots.	
Potash	121.8	128.9	250.7	220.0	337.04	117.04
Soda	42.6	22.4	65.0	76.34	96.14	19.8
Lime	46.2	18.48	64.68	82.50	89.22	16.72
Magnesia	36.1	16.72	42.82	66.66	81.18	14.52
Chlorine	42.6	25.08	47.68	76.34	98.34	22.0
Sulphuric acid	19.8	9.68	29.48	35.86	44.22	8.36
Silica	4.09	14.96	19.05	7.26	20.46	13.2
Phosphoric acid	29.43	25.96	55.39	52.80	75.24	22.44
Undetermined	26.79	7.04	33.83	31.24	36.94	5.70
Total	369.41	248.32	628.50	651.00	888.18	239.78
Dry matter	1,821.6	7,370.00	....	3,080	....	10,560
Nitrogen	43.56	110.0	....	83.6	....	176.0

"In France the general sources of supply of the various nutritive principles for the restoration of those removed by the crops, or to provide those required, are found in stable manure, seed cakes, animal wastes, woolen scraps, sulphate of ammonia, nitrates, superphosphates made from bones and minerals, potash salts, gypsum, and the scums and refuse from the sugar factories. Of all these substances, that which combines in itself in the highest degree all the elements of plant-food, and which is naturally the most economical, is the stable manure produced on the farm, and this being generally the result of keeping cattle to be fed upon the pulps from the factory is one of the sources of real profit to the producer.

"Joulie gives the following as the composition of French stable-manures of average quality, estimated in pounds per ton of 2,000 pounds:

	Manure of fifteen oxen.	Manure of ten cows.
Water	1,492.576	1,398.656
Organic matter	406.044	476.928
Mineral matter	101.380	124.416
Total	2,000.000	2,000.000
Nitrogen:		
Nitric	0.000	0.000
Ammoniacal	1.880	1.334
Organic	11.822	11.950
Total	13.702	13.284
Phosphoric acid	5.288	3.142
Sulphuric acid	3.010	3.000
Chlorine	2.740	4.000
Potash	19.104	20.832
Soda	5.164	6.284
Lime	14.538	14.060
Magnesia	3.770	3.478
Oxide of iron	1.304	1.250
Sand and silica	39.888	60.913
Carbonic acid and loss	6.574	7.438
Total	101.380	124.416

"A comparison of this table with that given before will show that in order to supply in stable manure the required nitrogen and phosphoric acid for the production of an average crop of 20 tons per acre, it will be necessary to apply at least 20 tons of stable manure to the same area. But this quantity will contain a considerable excess of alkaline matters over the quantity demanded by the crop, and will only tend to increase the saline constituents of the root at the expense of the sugar. This excess of mineral matters is often used to explain the production of roots of low saccharine value. Let us bring together the figures for the constituents of plant-food mentioned, as found in 20 tons of stable manure from cows and as found in the yield of an acre giving 20 tons of beets:

	Manure.	Beet crop.
	Pounds.	
Nitrogen	265.680	259.6
Phosphoric acid	62.849	75.24
Potash	417.040	337.04
Soda	135.680	96.14
Lime	281.200	89.22

"In practical work, therefore, it is found better to reduce the quantity of stable manures applied, and to supplement them with the other substances mentioned above. A comparison of the productive influences exerted by stable manures and by the artificial compounds usually employed to supplement it, or as substitutes for it, will be found in the following table, showing the results of the experiments made by Professor Deherain at the Grignon agricultural school, working with the Vilmorin improved race of beets. These results are interesting as showing the advantage of moderate applications of stable manures, and the choice that should be made in the supplementary compounds that should be applied:

*Influence of manures on yield in weight and richness in sugar.**

No. of the plots.	Manure distributed per acre.	Yield per acre.	Sugar in juice.	Sugar produced per acre.
		Tons.	*Per cent.*	*Pounds.*
1	9 tons stable manure	9.2414	12.67	2,351.80
2	18 tons stable manure	8.9893	12.58	2,228.60
3	36 tons stable manure	8.4378	11.28	1,896.59
4	36 tons stable manure and 890.7 pounds superphosphate of lime	8.7220	12.26	2,137.78
5	Without manure	6.1980	14.58	2,257.04
6	356 pounds nitrate of soda, distributed in one sowing	8.4378	12.75	2,184.01
7	356 pounds nitrate of soda, distributed in four sowings	8.7660	12.75	2,234.79
8	356 pounds nitrate of soda and 356 pounds superphospate, in one sowing	9.1220	13.23	2,415.46
9	356 pounds nitrate of soda and 356 pounds superphosphate, in four sowings	9.9235	13.08	2,568.24
10	1,068 pounds nitrate of soda, distributed in four sowings	8.5230	12.43	2,367.40
11	356 pounds sulphate of ammonia, distributed in one sowing	8.4378	13.89	2,336.25
12	356 pounds sulphate of ammonia, distributed in four sowings	7.7985	12.75	1,962.45
13	356 pounds sulphate of ammonia and 356 pounds superphosphate, in one sowing	6.5860	13.08	1,722.15
14	356 pounds sulphate of ammonia and 356 pounds superphosphate, in four sowings	6.9360	13.08	1,827.17
15	356 pounds superphosphate without nitrogen or manure	7.5205	13.24	1,990.93
16	1,068 pounds sulphate of ammonia, in four sowings	6.4970	12.42	1,693.57

*Journal des Fabricants de Sucre, November 13, 1878.

"Joulie* also found, in his experiments with stable manure and the different fertilizing compounds made according to his formula, that the largest yield was obtained with the complete manure containing all the leading elements. The next best yield was secured with the complete manure without potash; the next with nitrate of soda alone. The yields with the others decreased regularly in the order in which they are named. Without phosphate and without lime; with sulphate of ammonia; with stable manure; with nothing; with guano. From his experiments he concludes as follows:

"(1) The manure especially suited to the beet, and and which establishes the best conditions, as well for the yield per acre as for quality, is the complete manure B, of which the following is the composition:

	Per cent.
Nitric acid	6.500
Phosphoric acid, { assimilable / insoluble }	6.500
Potash	8.000
Soda	9.000
Lime	14.800
Water, sulphuric acid, silica, and other accessory elements	55.200
Total	100.000
The nitrogen corresponds to ammonia	8.000
The phosphoric acid corresponds to tricalcic phosphate	14.200

"(2) In soils provided with potash it (the manure B) is advantageously replaced by the manure F,† which differs only in the substitution of soda for potash.

Denomination of manure.	Nitrogen.			Phosphoric acid.			Potash.	Soda.	Lime.	Accessory elements.
	Ammoniacal.	Nitric.	Total.	Assimilable.	Insoluble.	Total.				
Manure A complete.	4.14	2.36	6.50	5.00	1.50	6.50	8.00	......	17.00	62.00
B complete.	....	6.50	6.50	5.00	1.50	6.50	8.00	9.00	14.80	55.20
C complete.	....	4.00	4.00	5.00	1.50	6.50	14.00	......	19.00	56.50
D complete.	....	2.50	2.50	8.00	2.50	10.50	8.00	......	20.00	59.00
E without potash...	6.50	....	6.50	5.00	1.50	6.50	....	......	19.50	67.50
E concentrated....	9.00	....	9.00	9.00	2.00	11.00	....	......	12.00	68.00
E without potash No. 2.........	3.00	....	3.00	14.00	2.00	16.00	....	......	22.00	59.00
F without potash...	....	6.50	6.50	5.00	1.50	6.50	....	14.00	15.80	57.20
G without nitrogen.	....	....	....	5.00	1.50	6.50	10.00	3.00	20.00	60.50
G without nitrogen No. 2.....	....	....	....	12.00	2.00	14.00	5.00	1.50	20.00	59.50

* Guide pour l'achat et l'Emploi des Engrais Chimiques, pp. 250 and 251.

† The conclusions of Professor Joulie will be better understood if reference is made to the accompanying table, showing the composition of the fertilizers, made according to his various formulæ.

"(3) These two manures should be applied at the rate of 400 pounds per acre upon soils in good condition and without stable manures.

"(4) Stable manure, applied at the rate of 20 to 25 tons per acre in the same year that the crop is grown, constitutes a bad condition, which it is prudent to avoid. It is better to reduce the stable manure to 10 or 12 tons and supplement it with a suitable addition of chemical manures. Thus putting the minimum of salts, particularly of potash, at the disposition of the roots, a better quality will be obtained.

"(5) If stable manure be applied at the rate of 10 to 12 tons per acre, which rate it has been found advisable not to exceed, the manure F without potash should preferably be employed at the rate of 200 pounds for good soils and of 400 pounds for poor soils. We thus avoid excess of potash, and establish between the useful elements an equilibrium favorable to the crop.

"(6) If fossil phosphates have been added to the stable manure after the method suggested by Baron P. Thenard, the manure F may be replaced by nitrate of soda at the rate of 260 pounds per acre for good soils and a maximum of 350 pounds for poor soils.

"(7) In no case should salts of potash (nitrate, sulphate, or chloride) be added to stable manure, which is always sufficiently rich in this element.

"From these and later experiments Mons. Joulie concluded, in general, concerning nitrogen of various compounds in its relation to the beet root and the influence upon its sugar content, that the nitrogen of the nitrates is more effective than that of ammonia, which in its turn is more valuable than that of organic matter.

"This difference in the elements of plant-food has also been noticed and determined by other workers, who have arrived at conclusions quite as marked as those of Joulie just given. Pagnoul* states that experiments made at Arras and elsewhere lead to the following conclusions concerning the use and abuse of nitrogenous compounds:

"(1) Abuse of all nitrogenous compounds, nitrates, stable-manures, seed-cake, etc., is always injurious to the quality of the beet.

"(2) Excess of nitrates by application before sowing is less injurious than excess of nitrogenous manures of organic origin. In fact the first are at once absorbed by the young plant favoring the development of leaves. On the contrary, the others act slowly and in decomposing may undergo nitric fermentation, which, favored by meteorological conditions, such as probably existed in 1875 to 1876, creates in the soil an abundance of nitrates, the retarding action of which impoverishes the root in the last days of growth.

"Concerning stable-manure, it is a fact that there is no necessity for prohibiting its use, because growers are generally wanting in it, and they will not be tempted to use it in excessive quantity to the same extent as they may be induced to use the mineral manures. But it is useful to show that this excessive use, if it were possible, would be even more fatal than the use of nitrates, as regards the quality of the root.

"(3) For the same reason the use of nitrates after sowing, and especially in the months of August and September, is absolutely bad, and may be characterized as fraudulent.

"(4) The abuse of nitrogenous manures, nitrates, and others is much less fatal when used upon rich varieties, and roots closely planted than upon poor varieties and roots cultivated at greater distances.

"(5) The causes to which the bad quality of the beets in our region (department of Pas-de-Calais) should be attributed are * * * the too great richness of our soils in nitrogenous matters, the abuse of manures, and the application of nitrates after sowing.

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* Journal des Fabricants de Sucre, 1878, October 13.

"Concerning stable-manures and the other nitrogenous manures used, M. Georges,* in a lecture on beet-root culture, advises that the quantity of stable-manure should not exceed 10 to 15 tons per acre, since this quantity will supply sufficient of salts for the needs of the plant. Nitrogen being the deficient constituent, should be supplied by some very soluble and easily-assimilable compound, such as from 250 to 350 pounds per acre of nitrate of soda, with an addition of a like quantity of superphosphate of lime, the latter element especially intervening to increase the richness in sugar. The prejudice against nitrate of soda is unjust. Judiciously applied it is useful. Only its abuse is disastrous, but neither more nor less than the excessive use of all others, and even stable-manure worked into the soil previous to sowing; it hastens the vegetation of the plant at the start and helps it through the first stages of growth. When it is exausted, the stable-manures, by their slow decomposition, supply the subsequent demands of the plant. But nitrate of soda should not be applied during the growth of the plant, because it may then remain in nature in the adult beet, which will not have time to elaborate it and secure all the useful effect. Sulphate of ammonia, with an equal quantity of nitrogen seems to be less favorable than nitrate of soda, because it is a salt which tends to rise to the surface in the soil, while the other descends to an equal extent. Other matters, such as seed-cakes, woolen wastes, etc., may be substituted for the nitrates, but they should in all cases be worked into the soil before sowing, that they may have time to decompose in advance and may be thoroughly mixed through the entire arable stratum.

"These ideas expressed by M. Georges were reiterated by M. Drouyn de l'Huys,† and express the views of all scientists and cultivators in France. But while all admit the value of the judicious application of the nitrates, it appears also to be the universal opinion that it should be accompanied by the application of a corresponding quantity of the phosphates, which have a tendency to counteract any prejudicial influence that the nitrates may exert by hastening the maturity of the plant and increasing its sugar content. This fact has been very nicely elaborated by Professor Maercker, of Halle, in a lecture lately delivered upon the subject of beet culture, an abstract of which may be found in the Journal des Fabricants de Sucre. He says it is a well-accepted fact that strong doses of nitrogenous manures are injurious to the beet crop, in that it increases the weight of the non-saccharine contents and reduces the sugar. The discredit into which the use of nitrates has fallen is due to its abuse and the manner of applying it. The difficulty appeared to be to determine the quantity to use and the best time to apply it. When applied too late it retards ripening. Applied in spring the plants develop vigorously in leaves and root and the period of growth is lengthened. So strongly nitrogenous manures always produce growth.

* La Sucrerie Indigène, 1878.

† Cõmpte-rendu des Séances du Congrès Agricole et Sucrèire tenu à Compiègne Mai, 1877.

"But the sugar-beet must ripen to accumulate sugar within it. Its growth should therefore be arrested to admit of ripening, which late distribution of nitrates prevents. At Magdeburg part is applied in the fall and the remainder before the preparation of the soil in spring. Heavy doses of strongly nitrogenous manures also necessitate heavy doses of phosphoric acid to annihilate the injurious effect of an excess of nitrogen. Phosphoric acid applied in large quantity induces early ripening of the plant. A mellow, permeable, clay soil may receive doses that would be injurious to a cold soil.

"Pagnoul has developed by his researches and observations that phosphoric acid gives varying results. In some soils no appreciable effect can be noticed, while in others its use has been found very favorable, and these differences are attributed to the greater or less proportion of phosphoric acid already existing in the soil. Notes should therefore be kept of the effects of various manures in order to avoid unnecessary expense in their application. M. Decrombecque considers that in all cases the phosphoric acid in the soil should be increased as the nitrogenous principles increase, and Woussen considers phosphoric acid a corrective for the deleterious influences of nitrates, because upon soils where nitrate of soda has been applied in large doses it is only necessary to increase the proportion of phosphates of lime to secure good maturation of the crop which would otherwise remain green.

"Pellet* has advanced some interesting notions concerning the comparative values of the different elements of plant-food in their relation to the production of sugar in the beet, deduced from the study of analyses of different plants obtained by various persons in their experiments. Lawes and Gilbert, discussing the analyses of wheats grown upon the Rothamstead farm, and of French wheats analyzed by Boussingault, conclude that wheat scarcely admits of a change in the composition of its ashes, whatever may be the composition of the fertilizers applied; the same is true of potatoes.

" But Pellet finds that the beet, on the contrary, may grow with equivalent substitutions of the alkalies necessary to the formation of sugar, so that, as shown by the experiments of Joulie, soda may be found in the ash of some beets in the same quantity as potash, while in others the quantity of potash is seven times that of soda. This substitution may also be noticed between lime and potash, but experience shows that though the alkalies may thus substitute each other, and lime, by equivalents, certain other bodies, such as phosphoric acid, will not admit of being replaced. The experiments of Champion and Pellet also show that in all plants we may observe a relation between the total weight of ashes and the special organic matters for which the plant is cultivated. Thus in wheat between the starch and total ash, and in the beet between the sugar and total ash. They construct the following table, showing

* Journal des Fabricants de Sucre, October 2, 1878.

in general that for the formation of 100 pounds of sugar in beets, the roots and leaves in their development must consume—

1 to 1.20	pounds of phosphoric acid.
5 to 6	pounds of potash.
1.5 to 2	pounds of soda.
1.5 to 1.6	pounds of lime.
1.2 to 1.4	pounds of magnesia.
2.7 to 3.5	pounds of nitrogen.

"Excess of all may be present in the soil, but if phosphoric acid be wanting sugar will not be produced, while if lime is wanting it will be replaced by potash or soda or magnesia, and this rule holds good for the other alkalies. The author therefore concludes that 1 of phosphoric acid corresponds to 100 of sugar, while 5 to 6 of potash corresponds to the same amount, and consequently phosphoric is worth 5 or 6 times more than potash in the formation of sugar, if potash replaces no other alkalies; in other words, if a soil be wanting in 60 pounds of assimilable potash per acre, there will be a deficit of 1,000 pounds of sugar, while for the same deficit only 10 pounds of assimilable phosphoric acid need be wanting. Phosphoric acid he considers a non-dominant but indispensable element or base for the formation of sugar in the beet.

"Reasoning from these data, they conclude that without experiment, but by examination of the average composition of the ashes and of the quantity of nitrogen in the plant, and comparing the total weight of the different constituents with that of the given proximate principle to be produced, for instance, sugar in the beet and starch in wheat and potatoes, it is possible, they say, to determine the order in which the elements of plant-food are indispensable for each plant. Thus, for the beet they range: 1, phosphoric acid; 2, lime or magnesia; 3, nitrogen, 4, potash or soda. On the other hand, the order for wheat is: 1, lime or magnesia; 2, potash; 3, phosphoric acid, etc. These are facts of great importance in the economy of providing supplies of plant-food, and they will aid greatly in the selection of the compounds to be employed for the fertilization of various crops.

"From what precedes and what we learn from the long-established practices followed in France in the application of fertilizers to the land on which beets are to be produced, it appears that nitrogenous organic compounds insoluble in water should be worked into the soil a long time in advance of the crop, and that to enjoy a beneficial result from their use they should be distributed at least during the autumn preceding the season of planting, and for stable-manures it is preferable that they be given to a preceding crop, which in France is generally oats or potatoes.

"Stohmann* says it is generally recognized as a rule that the sugar-beet should never be cultivated upon a fresh manure or barnyard manure, because this system of culture gives a large yield in weight, but roots so rich in foreign matters that they can not be worked with profit.

* Journal des Fabricants de Sucre, November 20, 1878.

The beet should always form the second rotation when the manure is strong.

"Other organic nitrogenous compounds, such as seed cakes, refuse animal matters, and even ammonia salts, may be applied in the fall or in the very early spring, while the nitrates, which are more soluble, may be applied either immediately before or immediately after planting.

"In no case should the latter be applied during the period of growth, on account of its influence, as shown by numerous experiments, to retard the time of ripening and the consequent maximum development of sugar.

"The quantity of stable manure per acre that may be applied to land to produce the most favorable effect seems in France to be from 8 to 15 tons, according to the character of the soil, and it is generally more profitable to use a smaller quantity and supplement it with nitrates and phosphates. The value of lime in its relations to the beet is no less than for other crops. Its disintegrating influence upon the nitrogenous organic matters is as important as its power to take the place of other alkalies which may be wanting. In fact, on account of this property, many of the most intelligent growers are inclined to use it, and by means of it to avoid in the juice many of the more objectionable soluble salts that the alkalies are likely to introduce. Another important consideration is its low market value, and the convenience of its application. At the same time, deficiencies of the other alkalies in the soil should not be overlooked, and they should be in all cases made up.

"It is scarcely necessary to further call attention to the importance and value of the phosphates in connection with this crop, after all that has been said. They may be applied at all times, and many growers consider it of advantage to distribute small quantities with each working or hoeing. The general method employed, however, is to distribute it in advance of the last plowing, in the course of which latter operation it becomes distributed throughout the entire arable layer. But if applied in the spring, it is considered by many that it should be deposited in the rows with the seed, and M. Derome is of the opinion that 100 to 250 pounds per acre applied in the rows will produce quite as good effects as 400 to 800 applied broadcast. He concludes from all his experiments, the results of which are confirmed by those obtained by Corenwinder, Pagnoul, Ladureau, and others, that artificial fertilizers worked in with the plow will give an average of about 3 tons more of beets than the same quantity of manure applied on the surface and worked in with the cultivators.

"The next consideration in the culture of the beet is the improvement of the physical qualities of the soil, and its preparation for the crop. The importance of drainage, etc., has already been referred to in the review of the inherent physical qualities of the soil which make it suited to this crop, and we may therefore proceed at once to the consideration of its manipulation to bring it to the favorable conditions before quoted.

And we shall first of all review the ideas advanced on this subject by some of the later writers who may be considered good authorities. Briem* says:

"The development of the beet depends, in the first place, upon good preparation of the soil, and its continued and careful maintenance. A preparation carefully effected brings about a mellowing of the soil, access and change of air and water, destruction of weeds, and deep growth of the root. Deep plowing (with steam where this is possible) is the first condition of a rational culture. This operation should be effected in advance of winter. Subsequent cultivation should not be spared. It improves the size and quality of the plant, and should be repeated as often and as long as the leaves will permit. The more the culture approaches that of a garden the more the quantitative and qualitative yield will be increased.

"According to Stohmann, beets do better after well-manured graminæ. They naturally find place in rotation after wheat and barley. In some cases beets have been produced two years in succession, but this is possible only in exceptional cases. It is injudicious to recommend a rotation of beets of less than two years. Immediately after a crop of cereals, the ground is broken up. In the fall, plow as deeply as the nature of the soil will permit, and leave the field with the furrows thus exposed during the winter to atmospheric influences. In the spring, prepare the soil for sowing by means of the roller and harrow; and in order not to lose the accumulated moisture of winter, avoid, as far as possible, plowing again in the spring.

"Vilmorin† directs to begin with an ordinary plow in the fall, followed by a draining plow, so that the ground will be broken up to a depth of 6 to 8 inches; and plow in the spring, and follow with harrow and roller. We can not more clearly give the prevailing opinions of French growers upon this matter of preparation of the soil than is expressed in the discussion on the subject in the meetings of the agricultural and sugar congress held at Compiègne in May, 1877, and published in the report of the procedings; and I therefore present below a translation thereof:

"M. Boursier said that it is, above all, necessary to work the ground and put it in such condition that it may be at the same time permeable and firm enough to adhere to the roots. This is effected by deep plowing and energetic harrowing and rolling. It would, nevertheless, be useful to elucidate this point, whether it is better to give a single deep plowing in autumn, followed by cultures with the scarifier and the harrow in spring, or to give several plowings, the first in advance of winter and the second immediately preceding sowing. For himself he considered it better to give a single deep plowing in the fall or winter.

"M. Debains prefers the system which consists in first giving a plowing to break up the stubble, followed by another to bury the manure, and finally a third before sowing.

"M. Blin said there was no necessity to have an absolute system with this regard. It would be dangerous to give a deep plowing to land having a shallow stratum of arable soil.

"M. Decrombecque had not adopted deep plowing, for the nature of his soils would

* Journal des Fabricants de Sucre, October 23, 1878.

† *Ibid.*, February 27, 1878.

not permit it; but in order to submit the greatest possible surface of soil to the beneficial atmospheric influences, he practiced the method of ridging.

"M. Boursier explained that by deep plowing he did not mean absolutely to say 14 to 16 inches; plowing is considered deep when it exceeds by 1 or 2 inches that of preceding culture. A plowing of 10 inches would be deep in ground which had never been broken up more than 8 inches; the depth is modified according to the soil.

"M. Demot called attention to the excellent effects of breaking up without displacing the subsoil (*i. e.*, subsoiling). With this system the production is sensibly increased. The use of the draining plow should be strongly recommended.

"M. le. Vte. de Chezelle called attention to the favorable effect of deep plowing shown by the vegetation on the sides of ditches opened for drainage.

"M. X. ——— responded that this fact does not constitute an argument in favor of deep plowing. In fact, in drainage the vegetal earth is always returned to the top while plowing brings the subsoil to the surface, and if this is not vegetal (fertile) it is evident that the operation is defective. He also insisted upon the use of the draining plow.

"M. Barral recognized the fact that deepening the arable layer is always advantageous in the long run, and he recommended attacking the subsoil only with precaution, and after taking into account its chemical composition. In this connection, as in the most of agricultural questions, it is impossible to fix an absolute principle, and it is always necessary to take account of circumstances. Besides it can not be denied that the beet is one of the plants for which the depth of the arable layer is of the, greatest importance.

"M. de Rougé has proven the excellent effects of deep plowing upon the poor clay soils of the extremity of the Aisne. Like M. Boursier, he counseled plowing in autumn. During the winter the land to be sown in the spring should be impregnated with the substances of the air and submitted to the favorable atmospheric influences. Broad furrows should be made in the first plowings given in autumn, because the more the earth is formed of large lumps the more the frost may penetrate by the wide spaces which separate them.

"M. Ch. Gossin remarks two unfortunate effects in the plowing which immediately precedes sowing the beet. (1) This plowing stirs up the soil in the interior. Now, the beet does not like light soils. (2) By this plowing we bring to the surface a quantity of bad seeds, which germinate at the same time as the beet, and cover the ground with weeds, while if the ground be plowed in the fall, the seeds which germinate in the early spring are killed in the operations of culture which precede sowing. Therefore in the triple regard of contact, of atmospheric agents, of the mellowness and internal cohesion of the soil and cleanliness of the ground, fall or winter plowing should be advised.

"The method of preparation followed in practice by M. H. Vilmorin is as follows: Begin plowing in November and break up the land 8 or 10 inches, and follow this with a subsoil plowing to a depth of 8 or 10 inches more, so that the ground will be thoroughly stirred up to a total depth of at least 15 inches. During the progress of this work, and as far as possible, the artificial fertilizer employed is distributed in the furrows before subsoiling. The ground is then left in the rough condition consequent upon plowing, and after that is twice plowed in spring, in February and April. It is finally prepared for sowing by harrowing and rolling.

"M. Champonnois considers it of advantage to prepare the ground in ridges before sowing, especially in working very shallow soils, in order to provide depth for the long tapering root, and put the ground in better condition for the circulation of air and water. He claims for his method of culture that it is less costly than the ordinary method, and gives a better quantitative and qualitative result. In his experiments he obtained 40 tons of beets per acre having an average richness of 18.50 per cent. and a co-efficient of purity above 83.

"The results of his experiments in 1878 do not seem to be as good as those obtained in previous years, as shown by the following table:

	No. 1.	No. 2.	No. 3.	No. 4.
Product per acre (tons)	28.300	40.450	22.500	11.725
Density of juice	6°.17	5°.45	6°.75	7°.5
Per cent. of sugar	11.37	9.61	14.90	16.91
Quotient of purity	69.70	66.69	83.94	86.0

OBSERVATIONS.

No. 1.	No. 2.	No. 3.	No. 4.
Seed, four kinds; richest, 12½ per square meter; fresh manure two months before sowing; earth beaten slightly on April 23, and after the beets had four leaves; complete manure, 200 pounds per hectare; culture given regularly.	Same culture and care; four kinds of seeds productive of weight; at November 1 beets were in full growth due to kind of manure and time of its application; beets short and rooty.	Manure well rotted; plowed in ridges; well beaten by rolling; manure-residues of elution containing salts and nitrogen of molasses; culture regular throughout entire growth.	No manure plowed in; chemical manure, 625 pounds per acre, worked in; sowed late; culture continued throughout vegetation; quality good; quantity wanting, explained by late sowing.

"However, in this matter of preparing the soil, as in all others, it appears that the grower, while following the general principles enunciated, must be guided by his own judgment and the character of the soil with which he has to deal.

"Sowing is generally effected by means of a drill especially designed therefor, but any drill that will deliver the seed regularly and in sufficient quantity will satisfy every purpose. The forms employed in France vary with the different inventions, but the spoon drill is the most common.

"The best time for sowing is considered to be the last week in April and the first fortnight in May, when the temperature should range from 50° to 60° Fahr., for at this temperature the seed will germinate most surely and most rapidly. The germinating faculty is materially increased by immersing it in water at 120° Fahr., and the beets produced are often richer in sugar on account of this treatment.

"Messrs. Champion and Pellet* give the following results of an experiment in growing seeds soaked in water and those not soaked:

	Date.	Average weight.	Sugar in beets.
		Grams.	*Per cent.*
No. 1, normal seed	August 31	400	16.4
	September 16	460	13.4
	September 29	580	17.0
No. 2, soaked seed	August 31	....	16.9
	September 16	500	14.9
	September 29	580	17.2

* La Bettrave à Sucre.

"Besides this, the beets produced with soaked seed had a better form than those from normal seeds.

"Various solutions have been suggested to be employed for soaking the seed, among others water slightly acidulated with nitric acid. Humboldt suggested very dilute chlorine water, but Ducharte showed that this was of no value.

"In many sections of France and Germany the juices flowing from the manure heaps are used for this purpose. They are diluted with an equal volume of water, and the seeds immersed in them for forty-eight hours. The seeds are after this time taken out, mixed with ashes, and passed over a screen. After this treatment they may be put in bags and kept in a cellar or other cool place until needed. When ready to be sown they must be quite dry on the surface, in order that they may not adhere to each other in sowing. Other solutions for the purpose have been used in France and Germany, the values of which, Basset† states, range in the order in which they are named:

"1. Mixture of urine and water in equal parts.

"2. *Purin*, or manure juices, pure or dilute, for which may be substituted ordinary water in which has been macerated guano, fowls' or pigeons' dung, so as to obtain a solution of a density of 1.015 or 1.020.

"3. Solution of nitrate of potash of 5 per cent.

"4. Solution of phosphate of ammonia of 2° B.

"5. Solution of superphosphate of lime 2 per cent.

"6. Solution of 2 to 2.5 parts chloride of lime in 100 of water.

"7. Dilute acid solutions of 1 to 1½ per cent., prepared only with hydrochloric, sulphuric, or phosphoric acids.

"Solutions of nutritive matters are considered more favorable to the purpose than pure water, because the latter in prolonged soaking will often remove from the seeds some of their soluble constituents. The length of time during which the soaking should be continued might vary somewhat, according to the temperature, but it is generally confined to forty-eight hours, and twenty-four are often considered sufficient. Basset states that during twenty-four hours seeds will absorb—

69 per cent. their weight of water at 39.9° Fah.
91 per cent. their weight of water at 50.8° Fah.
95 per cent. their weight of water at 60° Fah.
97 per cent. their weight of water at 65° Fah.

"Experiment has shown that seeds require, in a soil sufficiently moist and aerated, a total sum of degrees of average temperatures equal to 650° Fah. for germination. Thus if the average daily temperature be 50°, thirteen days will be required for germination; if it be 55°, then twelve days will suffice; and if 65°, only 10 days will be required. If, however, the seed be soaked for twenty-four hours in water at 100,°

† Guide Pratique du Fabricant de Sucre.

then the total sum of thermometric degrees, and consequently the number of days required for germination, will be correspondingly reduced. If they be soaked forty-eight hours at 100°, then only nine days will be required for germination in the ground at an average temperature of 50°, and a correspondingly less time with a higher temperature.

"With regard to the best time for sowing them, Basset* directs as a rule: "*Sow as early as possible according to the temperature of your locality, whatever may otherwise be the method chosen.*" Thus, when the temperature of the air is from 50° to 54° Fah. at noon, 46° to 50° in the evening, and 32° to 36° in the morning, sowing may be begun without fear of unfavorable temperature. This may be combined with observations of the temperature of the soil, which should at the same time have an average of about 45° at a depth of 4 to 6 inches.

"Concerning the depth to which the seed should be covered in the ground, opinions differ somewhat, but it will naturally follow that much must necessarily depend upon the temperature of the season, the physical condition of the soil, and the proportion of moisture. The seed requires the presence of oxygen for germination, and, therefore, if the penetration and circulation of atmospheric air be rendered difficult or impossible on account of a close, hard character of the soil, this function can not be exercised, and the seed will rot in the ground. If the soil be permeable and contain sufficient moisture, the depth of covering the seed will vary with the temperature. If this be too low, again, the seed will rot. But with a favorable temperature and a good physical condition of the soil, less attention may be given to the depth of seeding. However, it is considered a good rule not to bury the seed under any circumstances more than 1 to 2 inches, and experience has shown that at this depth, other things being equal, a higher percentage of the seeds will grow than at any other.

"In all of the beet-growing districts of Europe the system of planting in rows has been adopted, but in later years the attention and experiments of the progressive men have been directed to the determination of the influence of the distance between the rows and the beets in the rows upon the yield per acre and the saccharine value of the crops. In earlier years the practice was to separate the roots to such an extent that each square yard of surface should be devoted to six roots, but the experience of later years has shown that it is better to increase the number for this surface to ten. The extent of separation must naturally vary with the character of the soil and the seed grown. If in rich soils the roots be widely separated from each other they have at their disposition more of nutritive materials, and there is, of course, a tendency to the production of large roots, which, we have seen, will contain more of mineral and organic impurities and less of sugar. On the other hand, if grown more closely the stock of nutriment is less, the beets are smaller

* Guide Pratique du Fabricant de Sucre, p. 387.

and longer, and consequently richer. Yet, notwithstanding the smaller volume of the beet produced, the weight of the total yield per acre is very much larger than when the roots are separated to greater distances. These facts are amply illustrated in the results of the experiments of various workers in the sugar-growing districts of France.

"The following table shows the averages of the results obtained from experiments made by the Société d'Agriculture de Compiégne in concert with the Comité des Fabricants de Sucre de l'Oise. This recapitulation is made simply according to the separation, and without regard to the fertilizers employed.

[Distance between the rows, 18 inches.]

Distance between beets in the rows.	Beets per acre.	Average weight of a beet.	Density of pure juice.	Per hundred of juice. Sugar.	Salts.	Organic matters.	Degree of purity.	Saline coefficient.	Sugar per acre.
	Tons.	*Pounds.*	*Degrees.*						*Pounds.*
Ten inches	32,533	1.88	6.79	14.55	1.0823	2.0910	81.93	13.58	8,473
Fourteen inches	29,515	2.23	6.06	12.68	0.8195	2.2976	80.19	15.61	7,480
Eighteen inches	31,048	2.85	5.05	12.40	0.8700	1.0142	86.71	14.43	6,691

"Pagnoul's experiments, conducted during a series of eight years, gave similar results. He concludes that close planting gives beets which are (1) richer; (2) better quality; (3) of larger yield in weight; (4) less exhausting to the soil. He took, for his wider separation, 20 inches between the rows and 20 inches between the roots in the rows, and for the smaller separation 17 inches between the rows and 8 inches in the rows.

"(1) The richness of sugar in percentages of the weight of root was:

For the large distances 10.2
For the small distances 12.2

"(2) The proportion of alkaline salts, giving at the same time the measure of the foreign organic matters, was for 100 of beet:

With large distances 1.512
With small distances 0.722

"(3) With large distances there were 16,326 roots per acre, and with the small distances 46,122, or nearly triple. The yield in weight per acre was:

Tons.
With large distances 28.035
With small distances 36.045

"(4) The quantity of salts removed per acre would be equal in round numbers to:

Pounds.
With large distances 840
With small distances 520

"M. Pagnoul says in conclusion:

"Beets at small distances, while producing more of sugar, absorb less of saline matters.

"Now we know that the constituent principles of sugar are entirely furnished by the atmosphere, and that the saline matters are furnished by the soil and by fertilizers; therefore, *beets at small distances from each other* (*i e.*, closely planted) *are less exhausting to the soil.*

"Close culture is more profitable at the same time to the grower and the manufacturer.

Dubrunfant says:*

"The multiplication of subjects to avoid large roots, and to facilitate at the same time the production of a good constitution of the cellular tissue, is another condition to which great importance should be attached in the interest of richness in sugar.

"Briem says† 'the separation of the roots should be 15 by 10 inches.'

"In a late discussion in the meeting of the Cercle agricole du Pas-de-Calais,‡ it was developed that though the distance of 17 inches between the rows was still in use, it is gradually giving way to the wider separation of 20 inches, on account of the difficulties experienced in horse-hoeing and the deficient æration of the improved races of beets with strong foliage, which require more room.

"At the same time that the wider distance between the rows is adopted the roots are left closer to each other in the row about 8 inches; that is to confine them to from seven to nine roots to the square yard of surface.

"The experiments of M. Pagnoul, and results he obtained, together with the other facts and figures given, will be sufficient to show the importance of this matter of close planting, without quoting the results of the same character obtained by Corenwinder, Ladureau, Mariage, Pellet, Deherian, Vilmorin, and others; and we may conclude that for the methods of culture that must be employed in the United States where hand labor can not be obtained, the wider distance between the rows, 20 inches, should be adopted, separating the roots not more than 8 inches in the rows.

"The cultural manipulations proper of the crop should begin as soon as the beets are up and the leaves sufficiently developed to distinguish the rows; and we may accept the statement so universally reiterated by those who speak and those who write on the subject, as supported by the success of the practice, that 'early and frequent cultivation can not be too strongly recommended; it kills weeds scarcely started and forms a stratum of mellow earth which constitutes an obstacle to dryness by day and assimilates the moisture of the night.'

"As before stated, as soon as the rows are defined by the development of leaves the first cultivation by hoeing begins.

"In France this is, in many sections, performed by hand, while in others it is effected by means of the horse cultivator, the object being, of course, the destruction of weeds and stirring up the soil. At this time, also, many growers make an application of nitrate of soda or

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*La Sucerrie Indigène, xiii, 460.

†Journal des Fabricants de Sucre, October 23, 1878.

‡*Ibid.*, June 4, 1879.

potash. Two weeks later the beets are thinned out, so as to leave the roots about 8 inches apart from center to center, after the manner described above. After this the crop receives about three hoeings or cultivations, and more than this if time allows, for the work should be discontinued about the 1st of July, according to some authorities, or it may be continued as long as the leaves will allow, according to others. The latter will probably be for all localities and climates the better indication.

"After the final hoeing, about the 1st of July, no other care is necessary, with the exception of the removal of seed-stalks that may occasionally appear, especially if July and August be dry, until the harvesting, which should take place before the appearance of hard frost. If the roots be frosted in the ground they are rendered unfit for storing and preservation in caves or trenches for extraction of the sugar in the late winter, which is, of course, often necessary.

"Harvesting is generally begun about the middle of September, and may, according to the condition of maturity of the crop, continue until the middle of October.

"Pulling the roots is sometimes effected by machines that have been devised for the purpose, but the method generally employed is hand-pulling, the latter facilitated by the assistance of the pick or plow. In many cases a narrow furrow is made near to the row, which loosens the earth about the root and renders its extraction from the ground easier. The operation must in all cases be exercised with great care, in order that the roots be not bruised or cut, accidents which increase the tendency of roots to decay when stored. They should also be pulled when the ground is in the driest condition. If the ground be wet at the time of pulling, the earth will adhere to the root, and this will also produce a tendency to decay. Besides this, trouble will arise in the determination of the tare in the delivery of the crop to the manufacturer. In most cases the leaves are removed from the beet in the field, either at the time of pulling or at the time of charging them to the carts or wagons in which they are to be transported, either directly to the factory or to storage. If there be danger from the frost the roots are piled in pyramidal heaps, either before or after the removal of the leaves, in such a manner that they may be covered by their leaves or by straw. The leaves are removed by a knife or other instrument sufficiently strong and heavy that the operation may be effected at a single stroke. It is estimated that twenty laborers* (women and children) will be required to pull and prepare for transportation from the field the crop of an acre of beets in one day.

"But this estimate is made for French laborers, and we may calculate

* In the department of Seine-Inférieure ten laborers are generally employed for pulling the crop and preparing for transportation, five to pull the roots, and five to remove the leaves and tops.

that only half the number of laborers will be required in the United States to do the same amount of work.

"The beets to be preserved, if all surface moisture has not already evaporated from them, should, before being placed in trenches or cellars, be temporarily stored under sheds. Here the wounded, withered, or frosted roots, which would be subject to rot, are separated, if they have not already been in the field. The larger roots are also separated for the same reason. When thus separated and prepared they are ready to be stored. In the preservation the conditions to be avoided are too low or too high a temperature, too moist or too dry an atmosphere. With too low a temperature they deteriorate by freezing. This is not so injurious if the roots can be worked before they have an opportunity to thaw; otherwise, much of the cane-sugar changes over to inverted sugar, and must necessarily pass into the wastes in the processes of extraction. If too warm, similar effects will be produced by growth of leaves, as shown by Corenwinder and others. If too much moisture be present the roots have a tendeucy to rot, and if too little be present there will be a tendency to wither, and this effect is always accompanied by a loss of sugar, besides increasing the difficulty of extracting the juice from the root.

"The best temperature for preserving the roots in the fresh state, which is the condition of preservation most employed in France, is between 35° and 40° Fah. The equilibrium of moisture between the air and the root should be so maintained that evaporation may not take place; at the same time, as before stated, excess of moisture must be scrupulously avoided. Prudent cultivators consider that the roots should be so arranged in storage that they shall never be more than 3 feet from an air passage, in order to secure constant and regular renewal of the air to carry off noxious gasses, superfluous moisture, and regulate the temperature which always has a tendency to rise. The cellars or trenches must also be thoroughly drained, so that any water that may collect in the bottom may flow off. Temporary trenches are often made in the fields, but the more advanced growers are preparing permanent ones with well-paved bottoms and walled sides. They are generally 8 to 10 feet wide and 6 to 8 feet deep. I have seen them with walled sides 9 by 9 by 35 feet.

"Along the bottom of the ditch and through the middle of it is made a small trench to convey any water that may percolate through the walls or through the roots. Before the beets are placed in the trench the bottom is covered with poles, or in any other convenient manner, to keep the roots off the bottom and provide for free circulation of air under them and drainage of water. Straw is often used for this purpose, but is considered bad, because it is subject to packing and decay, and the latter will, of course, be communicated to the stored roots. They are then packed in the trench and covered with straw or leaves and finally with earth. The depth of covering must be determined by the climate. In the case of permanent walled trenches, which amount in reality to elongated cellars, I have seen them covered with a very thick thatch of straw, proper openings being provided for the necessary ventilation. In this way the roots may be preserved throughout the entire winter. If they should by accident be frozen they should be preserved in this condition until they are worked. Indeed this condition constitutes one of the modes of preserving them where a sufficiently low temperature may be maintained to keep them in this way unchanged without an opportunity for thawing, and is recommended by some authorities. In sections where excessively cold winters prevail it might be found a very convenient method for the purpose.

"Desiccation may be practiced where the method of diffusion or maceration has been adopted as the means of extracting the juice. It has the advantage of preserving the beet perfectly, with no danger from variations of temperature if the product be kept free from moisture or a moist atmosphere. They are also in the most favorable condition for ready transportation to any distance.

"For the purpose of drying, the roots are cut in slices, and in warmer climates placed in the sun, but in ordinary climates they are dried in ovens by artificial heat. The method has the disadvantage of requiring a double expenditure of fuel in evaporation, *i. e.*, for the removal of the water of vegetation and the water of diffusion employed for extraction of sugar.

"We see therefore that the experience of French growers and scientists proves that to secure the greatest profit from the culture of the beet the following points must be observed:

"Choose well-drained permeable soils, not overcharged with nitrogenous organic or soluble mineral matters. Choose the best qualities of seed. Give preference to smaller seeds. The best beets for all purposes are long, tapering, and smooth; do not grow out of the ground; are of moderate size and are dense and heavy. Plow deeply and as frequently as may be necessary to make the soil mellow. The more it approaches that of a garden in physical condition the more favorable it will be for culture of the beet.

"Be careful in choice of manures to be employed. Remember that insoluble and not easily assimilable nitrogenous organic compounds, before they can be of use to the crop, must be thoroughly disintegrated and decomposed. They must therefore be applied sufficiently in advance of the crops to secure this effect. Soluble nitrogenous compounds may be applied immediately in advance of or simultaneously with planting, and of these the nitrates are preferable. Nitrogenous compounds have a tendency to extend the period of growth and delay the time of ripening. This tendency is counteracted by the phosphates, in consequence of which they increase the production of sugar.

"Stable manures must in all cases be worked into the soil with the fall plowing. Do not apply more than 10 to 15 tons per acre, and supplement it with nitrate of soda and superphosphate of lime at the rate of from 200 to 400 pounds of each per acre, according to the character of the soil.

"Alkaline salts should be applied with great caution, and only to soils manifestly wanting them. They add to the cost of culture, and often reduce the industrial value of the crop. Plant closely; 18 to 20 inches between the rows will be found the most convenient and favorable for culture in the United States. Separate the beets by about 8 inches in the row.

"Cultivate early and often, and continue as long as the leaves will permit, but not longer than the middle of July. Do not harvest until the crop is thoroughly ripe, but it must not be allowed to be injured by frost.

"Store the roots in such a way that they may be protected from extremes of temperature and moisture, and observe care in ventilating trenches or cellars; otherwise the roots will rapidly deteriorate."

FERTILIZERS.

In respect to fertilizers, Stammer makes the following observations:*

"Manuring should first of all give back to the soil what the harvest has removed, both as regards mineral substances and nitrogen. Nothing can be more certain than that a soil to which this restoration is not fully made will gradually lose its faculty to produce plants in normal quantity and composition. Culture experiments with artificial food liquids have not been carried so far with the beet as with some other plants and, therefore, the dependence between the composition of such liquids and the evolution of the beet has not yet been determined. The basis is also wanting whereon the direct working of the manure on the beet can be predicted; and here is met the well known difficulty of getting the manures into those layers of the soil from which the beet chiefly draws its supplies

"From the present stand-point of our knowledge, therefore, the chief object of fertilization is the preservation of the favorable nature of the soil for beet culture.

"After what has been said it will not be matter for surprise that the numerous and laborious fertilization and cultivation experiments with beets have hitherto produced no generally applicable results; such can only be expected from the laws which will be established by the artificial cultivation of the beet in known nutrient solutions, and it is by no means a contradiction of this fact that the beet farmer should be advised to undertake fertilization experiments upon his particular soil. It is only a matter of ascertaining the particular form and quantity of

* Stammer *op. cit.*, pp. 170 *et seq.*

fertilizer which will best give necessary restitution under the local conditions, and such a form will doubtless in many cases be found, but it will be seldom possible to obtain from it a certain and constant influence upon the crop. The influence of those factors, over which we have no control—climate and weather—is always more powerful than the slight alterations which can be made in the character of the soil by the restitution of the elements taken from it, or by the preservation of the good character of the soil by fertilization.

"Since experience has taught that beets raised on fields freshly manured with stable manure are inferior for purposes of manufacture, the rule has long been established that not the beets, but the previous crop should be fertilized, or that the beets should be raised in rotation as the second or even third crop. Unfortunately this rule, so important to the factories, has not been so generally observed of late, and as a consequence of heavy manuring heavy crops have been produced, but at the cost of diminished sugar content or lessened price. This rule applies especially to stable manure and night-soil, as well as for Chili saltpeter, the misuse of which has had such serious consequence for factories, but not for phosphatic manures, which usually exert a favorable influence upon the crop.

"The constituents which are especially to be taken into account in the necessary restitution to the soil for beets are potash, phosphoric acid, magnesia, and nitrogen. Following are the quantities of these constituents contained in 1,000 pounds of beets and beet leaves, as given by averages from numerous analyses:

Constituents.	Roots.	Leaves.
	Pounds.	*Pounds.*
Potash	3.3	6.5
Phosphoric acid	0.8	1.3
Magnesia	0.5	3.0
Nitrogen	1.6	3.0
Total ash	7.1	18.1

"It will be seen from the relation between the roots and leaves that the amounts abstracted by the latter is considerably greater and deserves especial consideration in case the leaves are not left in the field. From this point of view the extensive practice of paying for the work of digging with the leaves is to be considered an evil and should be condemned. It is certain that a complete restitution can not be made in such fields. * * * The form in which the above mentioned plant constituents shall be returned to the soil is established for phosphoric acid and magnesia, and partly for nitrogen; superphosphates, with greater or less content of phosphoric acid, or with addition of nitrogenous element, are of universal application. The magnesia is returned in the press-cakes, as has been shown by direct investigations, pretty completely, though a more uniform distribution is much to be desired, which can be improved by thorough subdivision. It is advisable to institute investigations from time to time in regard to the phosphoric acid, and especially the magnesia in the waste products, and use them according to the results obtained.

"The question of returning the potash abstracted is more difficult; its computation is complicated by many uncertainties which can not be entirely avoided. Still this should not prevent the return of at least the difference between the potash in the entire crop and that contained in the refuse as nearly as it can be ascertained. Potash fertilization has largely fallen into disrepute chiefly because large and definite returns are expected from it, whereas the principal effect is to be expected in the *preservation* of the crop-producing qualities of the soil. These will surely suffer a decrease sooner or later in the succession of seasons if the restitution is not complete. A change can doubtless be expected when it is possible to fertilize the subsoil. Then for the first time will it be possible to judge of the direct influence of potash fertilization on the beet. A broader question, however, and one that may essentially influence the results in the case just mentioned, lies in the form of the potash compounds to be used, which is likewise true of the other fertilizing materials. There is scarcely a single point on which the views of practical men differ more widely, and new compounds are continually being recommended as the best. Only one rule seems to be of general application, that the potash salt should always be mixed with some common salt in order to insure its reaching the lower layers of soil; also the advantage of admixtures of magnesia salts if these are not given to the soil in some other way. Of the various potash compounds found in natural deposits none deserve preference over the others; this is due only, it seems to me, to compounds with organic substances. To give the reasons for this would require too much space; they will be apparent to the observant student of plant-life. Consequently the molasses, or its residue after distillation or the liquors of the molasses-working processes, all rich in potash, are themselves the most valuable materials for potash fertilization and should be carefully preserved for such use. It must not be supposed, however, that the demand of beet cultivation for potash will be satisfied by returning to the soil the molasses from the crop of beets in the form of waste products. Aside from the leaves, for which if taken from the field a largely increased potash return must be made, the molasses itself does not represent the entire amount of potash taken. Factories which produce raw sugar sell with it also potash, and in all factories the waste waters carry potash compounds, in small quantities it is true, but sufficient to account for the difference between the amount of potash in the beets and in the molasses. This is not simply a theory, but is based upon exact analyses of the factory waters.

"Although factories which sell refined sugar only, and by the purchase of after-products, or of foreign beets, may increase the amount of potash in their molasses above that taken from the soil in their own beets, and thus be able to make complete restitution by means of their molasses liquors, in most instances the contrary is the case, and to the sources of loss mentioned others must be added.

"That the potash fertilization is not sufficiently accomplished by the return of the molasses waste, however, is no reason why they should not be utilized as the most natural and suitable means towards that end. * * *

"To be sure there are great tracts of beet-fields where this is difficult or impossible, owing to peculiarities of location. For such, as well as for the unavoidable deficit, recourse must be had to potash salts, as must also be the case at first with many estates until an easier plan of molasses fertilization is discovered. Without going into the question as to what potash salt is to be preferred, or why such different results have been obtained from them, I would call attention to the fact that the certain results obtained from molasses-liquor fertilization indicate that the ordinary method of distributing the potash salt on the ground could well be supplanted by the solution of the salts in liquids which are rich in organic substances. It could certainly be expected that the application of, for example, sewage water in which potash salts had been dissolved, would be more likely to secure uniform distribution of the potash in the soil and in a better condition for plant nourishment than the application of small crystals of an inorganic potash compound. The same end can, of course, be attained in other ways. The salt may, for instance, be incorporated either as a fine powder or in concentrated solution with other fertilizing materials in a compost heap, etc. Experience and a few trials will soon indicate the best method.

"The advantages of such a mixture of potash fertilizers with stall liquor (the distribution of the salt in the stalls themselves is recommended by many) are given as follows by Frank:

"(1) The sulphate of magnesia in the potash salt holds the ammonia and the phosphoric acid of the manure.

"(2) Too rapid fermentation of the manure is avoided.

"(3) The prevention of the ammonia vapors arising from fermentation keeps the air of the stable purer and healthier.

"(4) The laborious application of the potash fertilizer is saved, and a much better distribution secured.

"(5) The cost of potash fertilization is cheapened, since the less expensive salt is better adapted for use on account of its content of magnesia.

"(6) The expense of the gypsum, which would otherwise be used, is avoided.

"There are also various methods for the use of molasses liquors; the simplest, sprinkling from potash casks, has been chiefly used heretofore, although illy adapted for an extensive establishment. The more complete system of underground pipes with the necessary openings in various places, as practiced, in England, is excluded on account of its cost. As a consequence the liquors have long been burned, and the slop ashes brought upon the field; but the fertilizing effect was lacking, although the restitution of potash was complete. Another difficulty was encountered in the loss of the nitrogen in the molasses, the value of this being nearly equal to that of the potash content. * * *

"The charring of the liquor is therefore inadvisable on two accounts, and only one resort is left; the evaporation of the liquor to such a degree as will admit of its profitable transportation. True, a very concentrated liquor can not be uniformly distributed on the field and must be further diluted on the spot, or mixed in compost with other fertilizers and thus brought upon the land. But a uniform distribution of the fertilizers, especially one saturated with liquids, demands very careful work.

"The absorption of either the thin or the concentrated molasses liquor by soil has also been productive of good results. But this method can not be universally used. The question of a cheap and uniform method for utilizing the molasses residues has become a very serious one in regard to molasses working, and can only be considered as settled for certain conditions.

"As for the relation which the quantity of material returned should bear to the quantity abstracted, it may be said in general that it is desirable to return as much nitrogen, one and a quarter to one and a half times as much potash, and two and a half times as much phosphoric acid as has been abstracted.

"I will say further that greater additions of potash and phosphoric acid have no disadvantageous effects upon the crop. * * * Direct investigations in regard to the relation between the sugar and potash in consecutive crops for many years have failed to give the least ground for a contrary conclusion. But it must not be expected on the other hand that increasing fertilizations, especially potash fertilization, will produce proportionately increasing crops, as has been asserted by some."

INFLUENCE OF NITROGENOUS MANURES ON THE QUALITY OF THE BEET.

The opinion has generally prevailed among beet-growers during late years that heavy nitrogenous manuring, especially with nitrate of soda, exercised no injurious effect on the quality of the beet. This opinion was based on the fact that in such beets the sugar per cent was only slightly diminished. Nevertheless the quality of a beet may be impaired even with little or no diminution of the sugar content by reason of the increase of the percentage of non-sugars present.

Herzfeld* has shown that heavy manuring with nitrogenous substances greatly injures the quality of the beet for sugar-growing pur-

* Zeitschrift Rübenzucker Industrie, February, 1888, p. 131.

poses. In beets grown at Warmsdorf in 1887 the true co-efficient of the beet was found on unfertilized plots to be 69.2, while on the plots which had received large quantities of nitrogen it was only 65.1. In other words the unfertilized beets require that 31.8 parts of non-sugars must be removed in order to isolate 69.2 parts of sugar; while the proportions for the fertilized beets are 34.9 parts of non-sugar for only 65.1 parts sugar.

In beets from Atzendorf the injurious effects of Chili saltpeter were noticed in all cases; 30 per cent more of the nitrogen present in the beets being in the form of melassigenes than was the case with the unmanured beets.

The apparent co-efficient of purity of the juice is also frequently misleading since it takes no account of the nature of the non-sugars present. In beets grown at Bernberg the influence of strong Chili nitre on the maturing of the plant was noticed. Judged by the apparent co-efficient of purity of the juice alone, the beets which had received large quantities of phosphoric acid were the poorest, while those manured with Chili nitre were next, and the unmanured were the best. But no conclusion could be further from the truth than to suppose the beets grown with phosphoric acid were poorer than those which received the nitre. The latter contained three times as much nitrogen in the form of melassigenes as the former. The nitrogen, therefore, should be separated into albuminoid, betain, and ammoniacal groups. The term betain includes all organic bases which are precipitated with phosphotungstic acid. The real purity of the beet is also to be distinguished from the apparent purity of the juice. The real purity of the beet is obtained by dividing the percentage of sugar in the beet by the total solid matter therein; the apparent purity of the juice by dividing the percentage of sugar therein by the apparent percentage of solids as indicated by the Brix spindle. Judicious fertilizing with nitrate of soda, however, is beneficial, as will be seen by the statement of Dr. Peterman further on.

EXPERIMENTS WITH BASIC PHOSPHATE SLAG AS A FERTILIZER FOR THE SUGAR BEET.*

"Kuster concludes in the following expression that 'the basic phosphate slag is not adapted for application to heavy soils, and that the easily soluble phosphates are to be preferred in such instances.' Although some doubt may attach to a generalization based upon a limited number of experimental observations, the above conclusion may have a value in comparison with our experiments, notwithstanding that the methods adopted were not the same and the respective fertilizers contained differing quantities of phosphoric acid.

* By Em. v. Proskowetz, jr. Zeitschrift Rübenzucker Industrie, February, 1888, p. 127. Abstract.

"The experiments to be given were carried out at Kwassitz upon a heavy, humous, lowland soil, which had been previously planted with clover and wheat, and receiving a liberal dressing of farm-yard manure before taking the latter crop. The phosphate slag applied contained a total of 20.5 per cent phosphoric acid, of which only 0.04 per cent. was soluble in 'citrate solution.'

"The superphosphate used in comparative experiments contained in total phosphoric acid 17.3 per cent, of which 12.44 per cent was soluble in water.

I. Three plats received 6 kilograms slag in the fall.
II. Three plats received 8 kilograms slag in the fall.
III. Three plats received 8 kilograms slag in the spring.
IV. Three plats received 4.2 kilograms superphospate in the spring.

"*Yield in beets (roots without leaves) of the several plats.*

	Kilograms.
Unmanured	633
I. For 35 kilograms phosphoric acid, yielded	714
II. For 47 kilograms phosphoric acid, yielded	859
III. For 47 kilograms phosphoric acid, yielded	934
IV. For 20.7 kilograms phosphoric acid, yielded	1,600

"*Percentage of sugar contained in beets grown upon the several plats.*

Unmanured.	I.	II.	III.	IV.
Per cent. 14.3	*Per cent.* 14.3	*Per cent.* 14.1	*Per cent.* 14.3	*Per cent.* 14.4

"In this special instance it appears to be demonstrated that phosphate slag is less operative upon the heavy soils of this locality than the usual applications of superphosphates.

EXPERIMENTS WITH FERTILIZERS UPON SUGAR BEETS.*

"The experiments were conducted during the year 1889, and the results may be summarized as follows:

"(1) In two experiments it was shown that exclusive fertilizing with N-manures was effective and economically practicable.

"(2) In most experiments this year the application of P_2O_5 caused an increased yield. Most observable was the excess of value obtained from the use of the P_2O_5 in the form of superphosphate over the P_2O_5 contained in basic phosphate slag. It has been concluded that 2½ kilograms of P_2O_5 in form of phosphate slag are necessary to substitute 1 kilogram of P_2O_5 of the water soluble phosphate. The operation of the P_2O_5 of the slag phosphate is more moderate and constant than the P_2O_5 of the superphosphate, which latter has an earlier and more powerful effect on the young plant.

* By Em. v. Proskowetz, jr.

"(3) The percentage of optically active non-crystallizable matters has been extremely high this year, and was the highest where N-fertilizers were used and the lowest where the superphosphates were applied.

"(4) The experiments indicate that the basic phosphate slag should be used with reticence and discretion. Further, that the use of nitrogen mixed with superphosphates is in given localities the most safe and economical fertilizer."

The following observations in respect of fertilizing are taken from the report of Commercial Agent Howes:*

"MANURING.

"The sugar-beet, of all the cultivated plants, needs the greatest amount of nourishment in the soil. It is, therefore, very necessary to use such a manure as will supply it with the best nourishment and in such a condition that it can be taken up by the beet. Possibly some soils are rich enough to do without manuring, but this seldom occurs. There are cases were beets have been raised in the same fields for ten successive years without fertilizer, and yet good crops have been obtained.

"The ability of the sugar-beet to disclose and take up nourishment is not very high, and, therefore, if a large crop is desired, much manure must be used. Manure must be used that will increase the percentage of sugar as well as the quantity of the crop.

"According to E. Wolff, in 1,000 kilograms of sugar-beets are—

Constituents.	Roots.	Leaves.
	Kilograms.	*Kilograms.*
Water	815	897
Nitrogen	1.6	3
Ashes	7.1	15.3
Potassium	3.8	7
Sodium	.6	2
Lime	.4	3.1
Magnesia	.6	1.7
Phosphoric acid	.9	.7
Sulphuric acid	.3	.8
Silicic acid	.2	1.6
Chlorine	.3	1.3

"If we calculate per hectare (2.5 acres) 30,000 kilograms of beets (67,500 pounds) and 7,000 kilograms (15,750 pounds) of leaves, there is removed from the ground by beets—

Description.	Nitrogen.	Potassium.	Phosphates.
	Kilograms.	*Kilograms.*	*Kilograms.*
Roots	48	114	27
Leaves	21	28	5
Total	69	142	32

* Sugar-beet industry of Bohemia.

"STABLE MANURE.

"The direct application of stable manure to the beet is not good, because the beet will then not ripen at the right time, and the quality will be poor. Stable manure should not be put in the soil in the spring. It should be plowed under in the fall. The manure of sheep is worthless, as it contains too much nitrogen and potassium, and the amount of salts in the beets is so increased that they are hardly fit for the factory. Manure of cattle can be used if mixed with that of horses. This manure contains sufficient nourishment, but the amount of nitrogen in proportion to phosphoric acid is too high. This should be 1 to 2, but in this manure it is just the contrary. The amount of manure usually needed per hectare (2.5 acres) is between 20,000 and 40,000 kilograms. According to a table by Wolff there is produced in the ground by applying 30,000 kilograms of manure, 150 kilograms nitrogen, 78 kilograms phosphates, and 189 kilograms potassium. From this nourishment the result of applying freshly decomposed manure is, in the first year, 35 to 50 per cent; in the second year, 40 to 35 per cent; in the third year, 25 to 15 per cent. An average crop of sugar beets (30,000 kilograms) needs 69 kilograms nitrogen, 32 kilograms phosphates, and 142 kilograms potassium. Compost is a very good manure, but it is not good to use any sugar-beet soil in its preparation, as it may contain nematids.

"FERTILIZERS.

"In applying fertilizer not only the crop but the quality of the beets will be better if it be used alone or employed to modify stable manure. Generally nitrogen, salts, and phosphates are used; exceptionally, potassium. According to P. Wagner the following amount of phosphoric acid and nitrogen should be used.

Description.	Minimum per hectare.	Mean per hectare.	Maximum per hectare.
	Kilograms.	*Kilograms.*	*Kilograms.*
Dissolved phosphates	40	60	80
Nitrogen	20	30	60

"If nitrogen, as Chili nitrate, is used, then there will be needed 150 kilograms minimum, 250 kilograms mean, and 400 kilograms maximum.

"TIME FOR MANURING.

"Manuring should always be done as early as possible in the fall. The longer the manure has been in the ground before the vegetation of the beet the greater will be the amount of nourishment and its distribution. Experiments show that manuring in spring is wrong, and there are many reasons why. For instance, if the season is dry the manure can not decompose, the ground remains loose, and consequently the young plant suffers for water. On the other hand, as soon as a heavy rain comes after a drought the leaves grow very fast, but the plant does not ripen well, and a large crop is raised, but of a poor quality. If the manure is not decomposed the work in the field can not be done in good shape, and insects have a good refuge. On heavy, loamy soils fresh manure is good for loosening it and allowing the air to enter.

"*How deep to put the manure.*—It is best first to put the manure in the ground as shallowly as possible, because it decomposes better until the deep plowing is done. The more nitrogen the beet finds in the first period of its vegetation the better. The less nitrogen found in the ground in the first period the more will be taken up in the last period, and that means a loss for saccharification.

"The following table shows, by the experiments of Liebscher, that the crop may be increased without losing in quality, if the manure be properly applied and the beets planted closely:

Manure per hectare.	Sap.		Crop per hectare.
	Sugar.	Quotient in purity.	
	Per cent.	*Per cent.*	*Kilos.*
None	16.4	89.1	31,065
20,000 kilograms	16.3	87.4	34,785
30,000 kilograms	16.4	88.8	35,435
40,000 kilograms	16.2	89.1	42,100

"The more nitrogen there is in the soil the less fertilizer will be required, but the more phosphate.

"The increase of the crop by fertilizing with nitrogen is, according to experiments by Wagner: 100 kilograms Chili saltpeter with 15½ to 16 kilograms of nitrogen increase the crop about 4,500 kilograms of beets and 900 kilograms of leaves. Fertilizing with nitrogen should take place only when enough phosphate, lime, and potassium is in the soil, because large and good crops can only be expected when these substances are present. Whether enough phosphate is present can only be learned by experiment. Fertilizing with nitrogen should only be done in the spring. Chili nitrate should always be preferred, and the following rules should be observed:

"(1) A good variety must be planted.

"(2) Seeds should be obtained from the best sources.

"(3) In addition to Chili nitrate, phosphate must be added, or the crop will mature too late.

"(4) Fertilizing with Chili nitrate should be done before sowing, not after.

"(5) Beets must be thickly planted, and cultivated four or five times.

"According to the calculations of Stutzer, the use of more than 400 kilograms to the hectare of Chili nitrate does not pay.

" Professor Mærker has experimented upon the influence of phosphates with the following results:

" Phosphates do not always produce an effect. If the soil is supersaturated with it, it can cause loss. This has often been observed by practical farmers. The cause is that P_2O_5 quickens maturity or causes an early death of the leaves, and that may lessen the crop, especially in a dry, rainless season.

" Ten experiments have given the following results:

Fertilizer.	Crop per hectare.	Increase.
	Kilograms.	*Kilograms.*
Without phosphate (P^2O_5)	32, 063	....
400 kilograms precipitate	34, 456	2, 393
Superphosphate (P_2O_5—76 to 80 kilograms)	35, 346	3, 283
400 kilograms Thomas slag	33, 589	1, 526
1,000 kilograms Thomas slag	34, 756	2, 693

" There is not much difference in the effect of the various phosphate fertilizers so far as sugar in the beet is concerned. If it be necessary to use phosphate fertilizers in spring, superphosphate is always to be preferred.

" SPREADING THE FERTILIZER.

" Spreading broadcast has been found to be better than drilling. This is done by the machine shown in Plate 1.

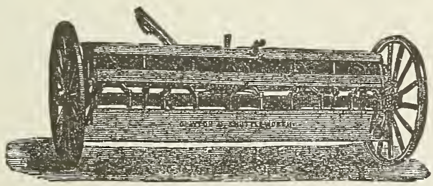


FIG. 36.

" There are, however, drills which have an attachment for drilling fertilizer, as is shown in Plate 2.

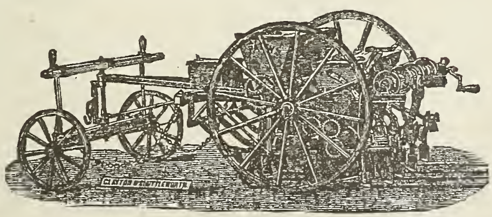


FIG. 37.

" It is very important to put the fertilizer in the right depth. Prac tical experiments have shown that it should not be used after sowing. In using Chili nitrate, a shallow harrowing is sufficient, because the next rain will carry it deeper. Potassium and phosphate, which are absorbed immediately, must be put deeper. This can be done with a sharp harrow, or, better still, by shallow plowing. It is said that a depth of 20 to 22 centimeters is the best.

"The following table shows the results of different depths in sandy loam soil per hectare:

Year.	Depth.		Difference.	
	10 to 12 centimeters.	20 to 22 centimeters.		
	Kilograms.	*Kilograms.*	*Kilograms.*	*Per cent.*
1881	32, 674	38, 543	5, 869	17. 96
1882	36, 217	39, 030	2, 813	7. 77
1883	65, 726	69, 596	3, 870	5. 89

"MIXED FERTILIZER (PHOSPHATE AND NITROGEN).

"Of these are used: Peruvian guano (7 per cent nitrogen to 10 per cent $P_2 O_5$) ammonia superphosphate; blood manure with superphosphate. Bone-dust is seldom used, as its effect is too slow; if used, it must be applied in the fall.

"Although most soils have potassium enough, it may occur that lands where beets are raised every year may need it. The direct application of potassium salts to the beets is not good, because all these salts contain a chloride which injures the plants. The best is to give potassium mixed with stable manure two years before the beets are planted. When thus mixed, the ammonia is kept from becoming volatile.

"*Lime.*—Quicklime is a good fertilizer, especially on very heavy soils, which it loosens. For 1 hectare 24 to 40 kilograms should be used.

"For sandy soils marl is excellent, the best containing 30 to 50 per cent of lime. The amount of marl needed for 1 hectare, if containing 30 per cent of lime, is 220 kilograms; if containing 50 per cent, only 130 kilograms."

In general it may be said of fertilizers that they must be judiciously applied if a maximum benefit is to be secured. Especially is this true of nitrogenous fertilizers, which, when applied to soils already rich in nitrogen, or in excessive quantities or at inopportune seasons, may, by delaying the maturation of the crop and decreasing the relative percentage of sugar, prove injurious. Nitrogenous manures should be applied to the soil and thoroughly incorporated therewith before seeding, and should in general be supplemented with phosphate and potash fertilizers. The quantity of nitrogen may vary from 15 to 30 pounds per acre. A fertilizer containing about 14 per cent. of nitrogen should therefore be used in quantities of from 125 to 250 pounds per acre.

STUDIES ON THE DEVELOPMENT OF THE SUGAR-BEET.*

In a most valuable brochure of 87 pages, with six figures and ten heliograph plates,† Girard has traced the development of the beet from the beginning of its growth to complete maturity. In its various stages the proportional weight of roots, stems, and leaves has been established and the development of sugar traced. In Plate 1 complete plant at maturity is shown.

This weight of the entire plant was found to be 1,527 grams.

This weight was divided as follows:

Leaves:		
Stems	grams	161
Leaf	do	376
Body (containing 12.19 per cent sugar)	do	965
Top, root, and radicles	do	25
		1,527
Extreme length of root	meters	2.5
Surface:		
Foliage	sq. centimeters	3,520
Body	do	417
Radicles	do	2,920

GENERAL CONCLUSIONS.

Girard, as a result of his studies, calls attention to the origin of the sugar which the body of the beet has stored up and the fact that its development has been followed step by step.

To comprehend well the storage of sugar it is necessary to get an exact statement of the absolute and relative growth of the three principal parts of the beet, viz, body, foliage, and radicles. These proportions at various periods of growth are shown by the following table:

	Body.	Foliage.	Radicles.
	Per cent.	*Per cent.*	*Per cent.*
June 8	6.8	83.1	10.1
June 19	15.1	80.1	4.8
July 2	24.8	72.8	2.4
July 15	29.5	68.5	2.0
July 29	38.9	59.3	1.8
August 10	45.7	52.8	1.5
August 24	52.0	46.2	1.8
September 5	57.3	41.2	1.5
September 18	59.8	38.7	1.5
October 1	63.3	35.2	1.5

The preceding numbers permit the general character of the plant to be recognized at once during the various periods of its growth. During the first two months the organs pertaining to the foliage are predominant and the activity of the plant is principally directed towards

* By Prof. Aime Girard. Abstact.

† Published by Gauthier-Villars, 55 Quai des Grands-Augustin, Paris.

the production of these parts. The importance of the body during this time is of little moment. In respect of the rootlets, their relative importance is pronounced at the beginning of growth, but rapidly diminishes and soon less than 2 per cent of the weight of the plant represents the radicles. During the last two months of the season vegetation goes on under entirely different conditions.

The foliage and rootlets increase, it is true, but in such feeble proportions as to often seem stationary. The body on the contrary increases rapidly in weight, and at the end of the season it represents about two-thirds of the entire weight of the plant. For each of the parts of the plant in normal conditions of soil humidity this increase is regularly proportioned to the time of growth, and would be represented graphically by almost straight lines, and this is true of body, rootlets, and also for the foliage, provided the normal weight of the withered leaves is taken into account.

Unequal in point of view of intensity for each of the parts, feeble for the foliage and roots, considerable on the other hand for the body, this increase preserves its regularity in respect of the components of all the parts, viz: Cellulose, mineral matters, organic soluble matters, that is to say, matters in course of elaboration. In such a manner is this growth carried on that by leaving out of account intermediate products, it may be said that all the parts of the plant maintain a sensibly constant composition during the most important period of growth, viz, from the month of July on. There are, however, some exceptions to this rule, and although they are not numerous, they are of great importance both from a vegetative point of view and from industrial considerations. Thus the analysis of the roots and rootlets shows them increasing rapidly in vascular tissue and acquiring, by reason of the increase in cellulose, a daily increasing solidity. In like manner the study of the foliage, and notably of the leaf, discloses the presence of sucrose, varying in a relatively important manner under the influence of the light, while on the other hand the products comprising the other vegetative tissues vary in a manner much more restrained.

Also, finally, the study of the body at different epochs of vegetation shows an increasing saccharine richness, intimately connected with meteorological conditions, and notably with the measure of rain which the plant has received. In a word, it is shown that the body increases regularly in weight, whatever be those conditions, but being charged either with water or sugar according to circumstances, and preserving in all cases the sugar which previous vegetative activity has stored up.

From the considerations which precede, it seems possible to define the conditions under which the sugar-beet is developed, the conditions under which the important quantity of sugar is formed which the body has stored away.

From the first months of its vegetation the sugar-beet asserts its coming character, for even when its weight does not exceed 1.5 grams it contains already 1.5 per cent sugar. Its chief activity at that time, however, is to perfect its foliage and rootlets. But soon, from about the middle of July, its vegetation takes on a different character. Each day, under the direct influence of the sunlight, the leaves form a new quantity of sugar. Each day along the petioles a quantity of sugar, which may be roughly estimated at 1 gram, passes to the body. In the same time there is taken from the soil in aqueous solution a quantity of mineral matter which may be estimated at .15 to .20 gram, and this matter is directed through the body toward the leaves.

The essential part of the plant, that body which at the end of the season represents two-thirds of the whole weight of the plant, ought therefore, no longer to be considered only as a vegetable plexus which, during the first year of the life of the beet, increases regularly with the time, and of which the cellulo-vascular tissue of a composition, sensibly constant during the entire period of vegetation, is filled regularly with water and sugar, the one replacing the other according to meteorological circumstances, and forming in all cases a sum which represents about 94 per cent of the weight of the beet.

CONTRIBUTION TO THE CHEMISTRY AND PHYSIOLOGY OF THE SUGAR-BEET.*

"(1) The application of the chemical fertilizer composed of nitrate of soda, chloride of potash, and superphosphate of lime in quantities which replace the fertilizing principles removed by the last crop is capable of retarding the germination of the seed, in some cases, for as much as three days, according to the degree of humidity in the soil. Two causes contribute to produce this phenomenon; on the one hand the free phosphoric acid and alkaline salts act as antiseptics on the ferments which cause the germination, and on the other hand the chemical fertilizer being very hydroscopic, takes from the seed a portion of the moisture necessary to soften the outside of the seed.

"(2) The morphological development of the sugar-beet is modified under the influence of its environments, that is to say, under influence of different nutriments.

"(3) Maturation of the sugar-beet, which is indicated by the disappearance of the chloroplyll in the leaves, is retarded by the application of nitrogen in the form of nitrate of soda.

"(4) In spite of the production in the same soil of eleven successive crops of sugar-beets the nematoid has never been discovered.

"(5) The quantity of water which traverses a cubic meter of the earth depends on the one part upon the rain-fall, and upon the other on the vigor of vegetation, being directly as the first cause, and inversely the second.

* By A. Petermann. Bulletin of the Association of French Sugar Chemists, December, 1889, p. 253. Abstract.

"(6) Drainage water is more rich in nitrogen where nitrate of soda has been used than where other mineral salts have been employed.

"(7) In a clayey, sandy soil, the regular restitution of the mineral matter alone and of the nitrogen alone, and of the mineral matter associated with the nitrogen, removed by the preceding crop has increased for the ten years of experiment, the production of organic substances respectively from 27 to 50 and 93 per cent, compared with the production obtained without restitution of the nutritive elements. The natural sources of nitrogen are insufficient to show the maximum utilization of the mineral matters restored alone; and, moreover, the decomposition of the soil does not render assimilable sufficient quantity of the mineral matters to permit the sugar-beets to produce, with the aid of restored nitrogen alone, the maximum of organic matter.

"(8) The great oscillations observed in the weight of organic matter produced from year to year, can be caused only by those factors of the experiment which are changeable, namely, meteorological conditions.

"(9) In the experiments made, the production of organic substances the minimum of heat necessary to normal development being furnished, is shown to depend rather upon the height of the rain-fall than with the degree of heat.

"(10) All the conditions being equal and the minimum of the heat necessary to the normal vegetation being furnished, the quantity of sugar contained in the beet at the moment of harvest is in direct proportion to the intensity of light which has prevailed during the whole duration of vegetation.

"(11) In our assays, the centesimal composition of the ash has varied essentially with the environment and has been modified from year to year.

"(12) The quantity of certain mineral elements, phosphoric acid, lime, and magnesia found for a given year are almost in the same proportions in the beets where they are not fertilized as in the others. It is therefore shown that this vegetable absorbs for a given weight of organic substance produced these mineral elements in a certain proportion more or less fixed according to whatever be the proportion of the quantity placed at its disposal.

"(13) The absorption of mineral matters has taken place in the case of lime and magnesia, in the state of phosphate and carbonate, and in the case of potash and soda in a state of chloride, sulphate, and nitrate.

"(14) The quantity of water contained in the beet is a characteristic of the variety; certain variations are noticed from climatic conditions, etc., but in general, the character of the food furnished the plant is without influence upon its richness in water.

"(15) Albuminoids and fats vary greatly in the beets and the extract matters also, while the content of sugar and of cellulose is more constant.

"(16) Of the total nitrogenous bodies contained in the beet at maturity, 58 per cent belong to pure albumens, and 42 per cent to the albuminoids such as the amides and albuminoid glucosides.

"(17) The application of nitrate of soda has exerted a slight depression on the formation of sugar. The diminution of the percentage of sugar due to the nitrogen is more than compensated by the energetic action of this fertilizing principle on the production of total organic substance, and it may be definitely stated that in spite of the decrease in percentage, the total weight of sugar is increased. The total sum of the carbohydrates has been almost the same in all the ten experiments irrespective of the food furnished the plant and has varied chiefly by reason of the intensity of the light.

"(18) The cellulose also has shown little variation."

TYPICAL FORMS OF SUGAR-BEETS.

The shape of the sugar-beet has much to do with its value as a sugar-producing plant. A smooth and symmetrical exterior permits the beet to be easily harvested and washed. An irregularly shaped beet may easily carry into the cutters sand and earth, and even stones of considerable size, quickly dulling and even breaking the knives of the slicing machine. In selecting mothers, therefore, only beets of smooth and symmetrical exteriors are chosen.

There is thus a tendency to establish a typical form, which varies with the variety of beet. These typical forms for the most approved varieties of beets have been carefully studied and photographed by Professors Eckenbrecher and Maercker, and a few of the most important of these types are reproduced here. In addition to the beets of normal types, there are noticed a few instances of reversion to older and less desirable forms.

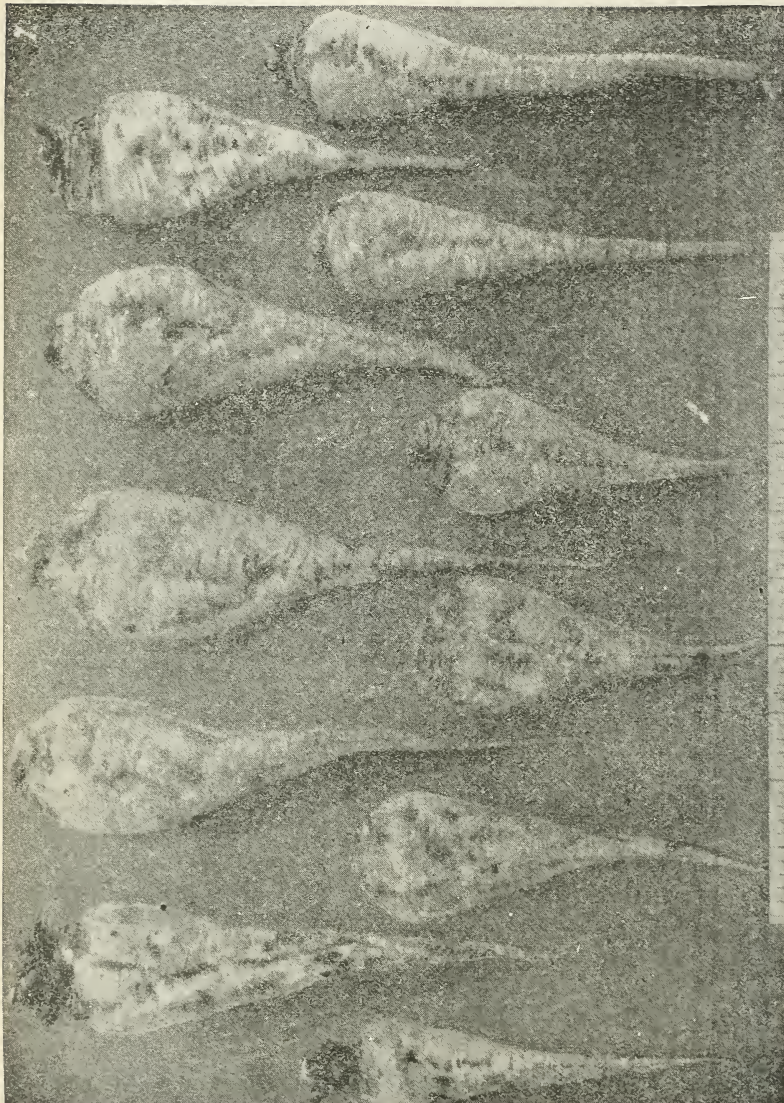


FIG. 38.—Typical Forms of Sugar Beets—Variety, Improved Klein-Wanzleben. Schlitte & Co., Anmühle.

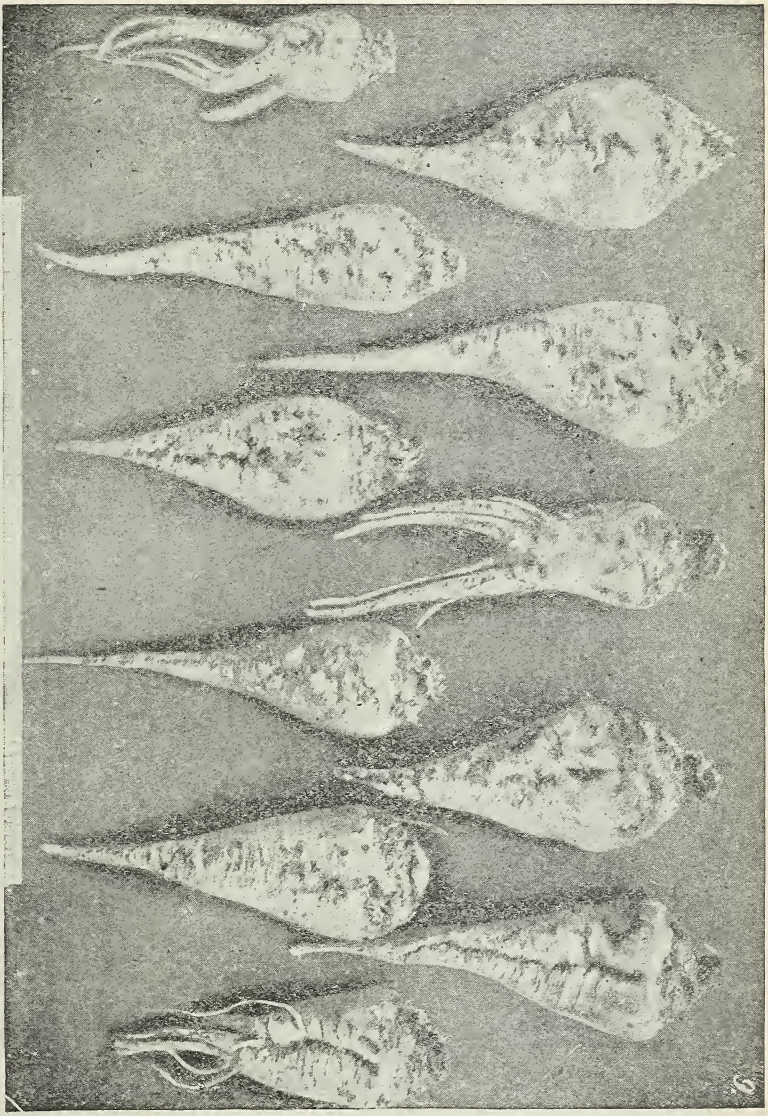


Fig. 39.—Typical Forms of Sugar Beets—Variety Vilmorin. Körbisdorf Sugar Factory.

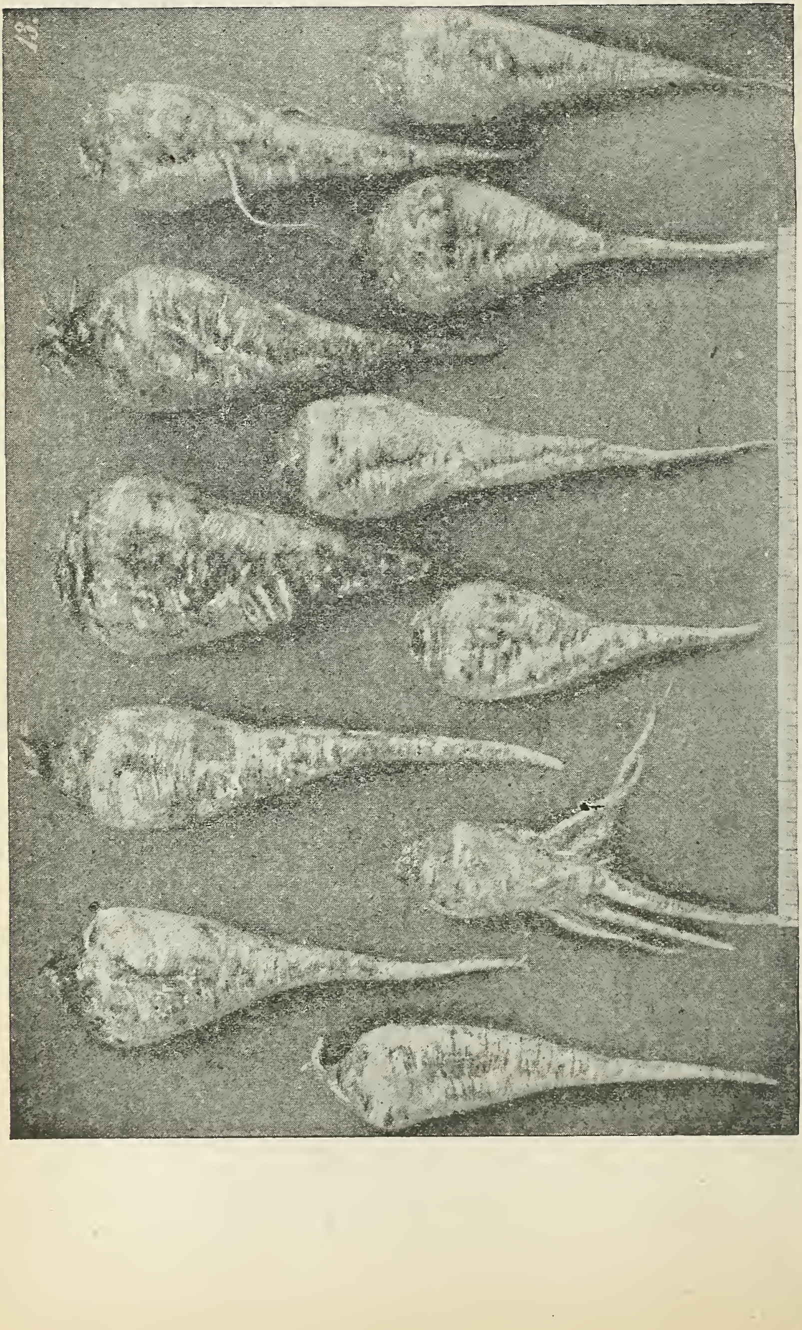


FIG. 40.—Typical Forms of Sugar Beets—Excelsior White, G. Bestehorn.

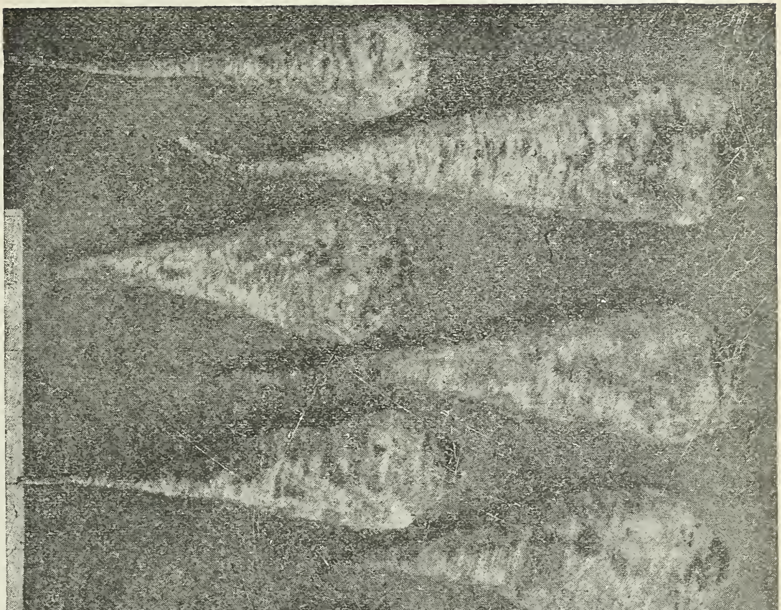


Fig. 41.—Typical Forms of Sugar Beets—White Improved Imperial White Rose Heart. Martin Grosshoff, Quedlinburg.

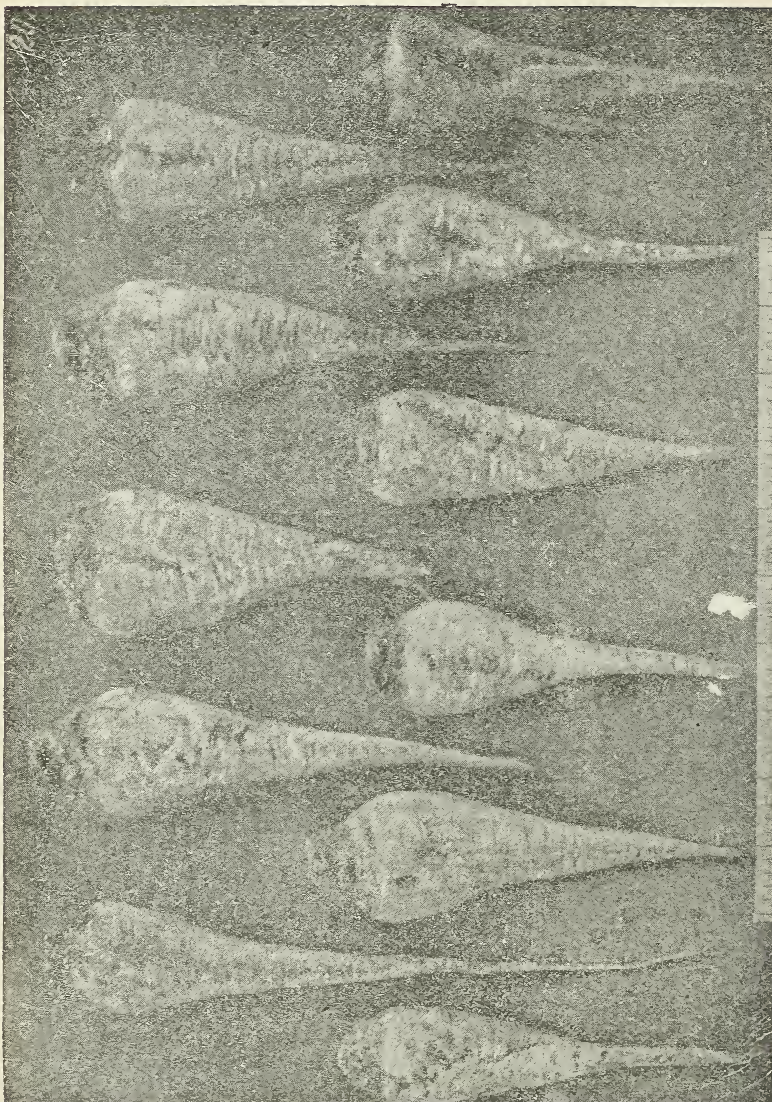
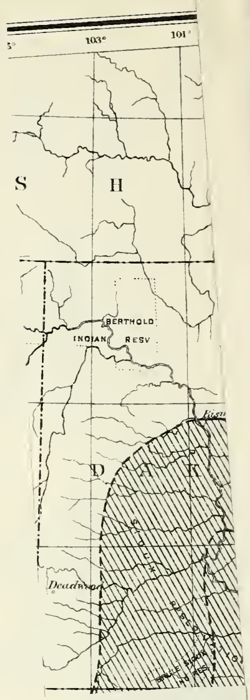


FIG. 42.—Typical Forms of Sugar Beets—Improved White Klein—Wanzleben. Dippe Bros., Quedlinburg.


103°
101°
S
H
BERTHOLD
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Deadwood

METEOROLOGICAL CONDITIONS.

In addition to suitable soil fertilizing and cultivation the sugar beet requires certain meteorological conditions for the highest production of sugar. Temperature and rain-fall exercise the most pronounced influence, not only on the yield of beets but also on their saccharine qualities.

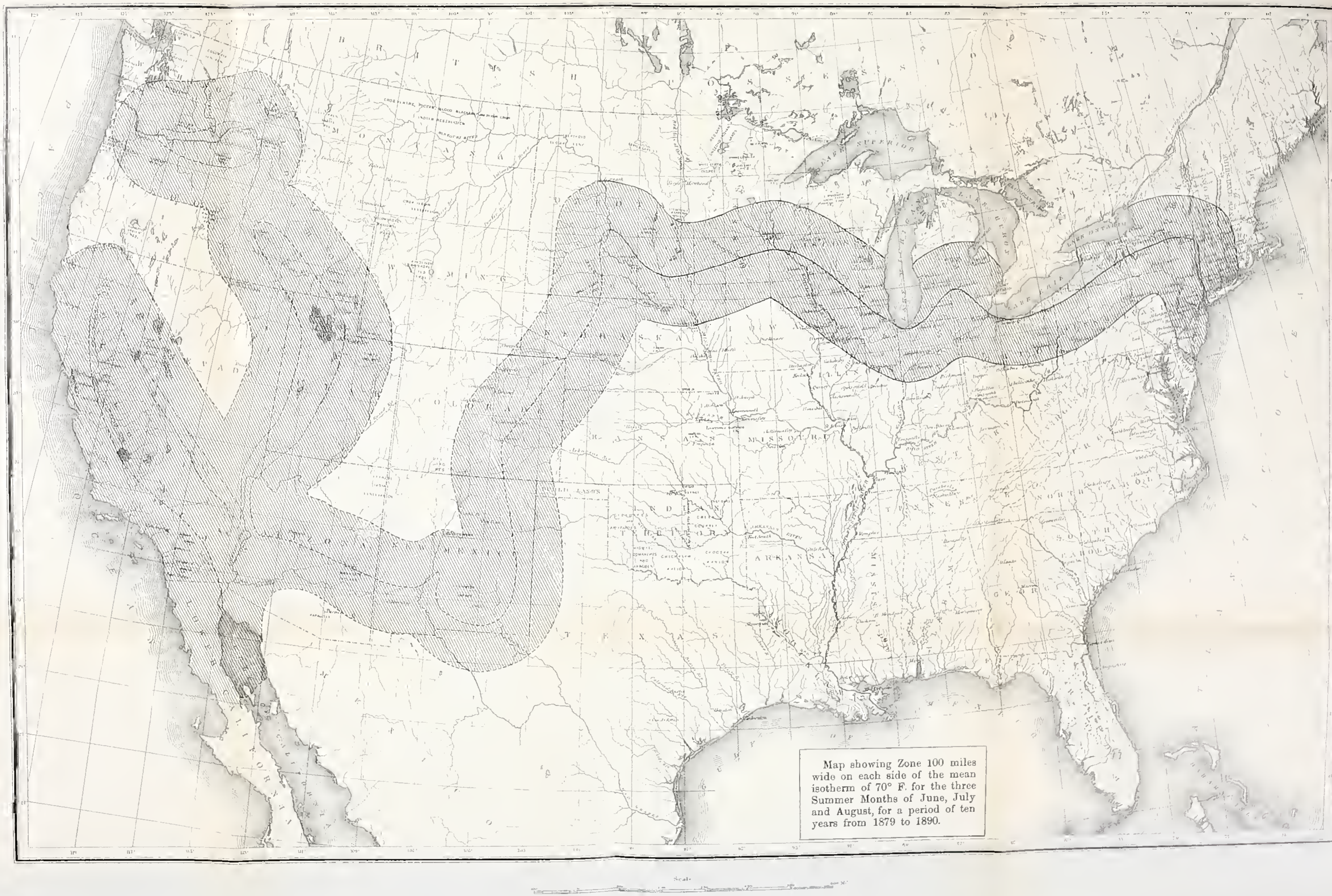
A mean summer temperature of 70° Fah. for ninety days is sufficient to push the beet well on to maturity, while a much higher degree than this tends to diminish its saccharine strength.

The experience of beet-growers in California indicates that in certain latitudes the beet can flourish with a much less rain-fall than has hitherto been deemed a minimum for its proper growth; but this is not conclusive evidence that in all localities so small a supply of moisture would be sufficient. In regions of dry and hot winds or where the subsoil was less porous, or aerial evaporation much more vigorous, less favorable results would be obtained. Dr. McMurtrie traced his area of beet-sugar limits with an isotherm of 70° Fah. for the summer months, and a minimum rain-fall of 2 inches per month for the same period. By the kindness of the Signal Office I have obtained a record of mean temperatures and precipitation for each month in the year for a period of ten years of those portions of the country in which the culture of the sugar-beet is most likely to succeed. Also from the same source a tracing of the mean isotherm of 70° Fah. for ten years for the three months of June, July, and August. Extending for 100 miles on either side of this line, the map shows a belt extending from the Atlantic to the Pacific, within whose limits the most favorable conditions for growing beets, as far as temperature alone is concerned, will be found.

The mistake must not be made of supposing that all the region included within the boundaries of this zone is suitable for beet culture. Rivers, hills, and mountains occupy a large portion of it, and much of the rest would be excluded for various reasons. In the western portion, perhaps all but a small portion of it would be excluded by mountains and drouth. Beginning at a point midway between the one hundredth and one hundred and first meridian, as indicated by the dotted line, beets could be grown only in exceptional places without irrigation. On the Pacific coast, only that portion of the zone lying near the ocean will be found suitable for beet culture.

On the other hand, there are many localities lying outside the indicated belt, both north and south, where doubtless the sugar beet will be found to thrive. The map, therefore, must be taken to indicate only in a general way those localities at or near which we should expect success to attend the growth of sugar beets in the most favorable conditions other than temperature alone.

In respect of the rain-fall it is necessary to call attention to the fact that a wet September and October are more likely to injure a crop of



Map showing Zone 100 miles wide on each side of the mean isotherm of 70° F. for the three Summer Months of June, July and August, for a period of ten years from 1879 to 1890.

sugar beets than a moderately dry July or August. A wet autumn succeeding a dry summer is almost certain to materially injure the saccharine qualities of the beet before it can be properly harvested. In this regard it will be seen from the tables of precipitation that the two Dakotas are more favorably situated than Oregon and Washington.

The rain-fall in Oregon and Washington for September and October is 2.17, 3.25, and 2.24, and 4 inches, respectively, while in the two Dakotas it is only 1.11, 1.27, and 1.54 and 1.26 inches. The importance of this slight rain-fall in securing a safe harvest without danger of second growth is easily recognized.

During the winter months the temperature that is best for beets is one of uniformity and sufficiently low to prevent sprouting or heating in the silo. Sudden and extreme variations are alike injurious—on the one hand causing danger from freezing and on the other from sprouting. On the coast of California the winters are so mild that the beets require very little protection, in fact more from the heat than the cold, while in Nebraska and the Dakotas the temperature often falls so low as to endanger the beets even in well-walled silos.

All these problems in meteorology deserve the most careful consideration from those proposing to engage in the sugar-beet industry, and it is hoped that the subjoined tables and map may help to elucidate them.

Table showing the average precipitation, for each month of the year, at the stations specified. (Deduced from observations during the period January, 1880, to December, 1889.)

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maine:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Cornish	4.24	4.47	3.24	2.65	3.36	2.94	4.54	3.19	3.76	3.88	4.43	3.93
Eastport	4.64	4.49	4.68	3.14	4.82	3.72	4.49	2.82	3.16	4.89	4.22	5.26
Gardiner	5.02	5.20	4.27	3.31	3.53	3.09	3.47	2.48	3.62	3.80	3.86	4.64
Orono	4.52	4.64	4.06	2.76	3.60	3.29	3.70	3.33	3.38	3.76	4.44	4.45
Portland	4.22	4.72	3.23	2.90	3.42	3.04	3.96	3.23	3.51	4.02	4.21	4.44
	4.53	4.70	3.90	3.15	3.75	3.22	4.03	3.01	3.49	3.87	4.23	4.54
New Hampshire:												
Antrim	*4.61	*4.27	*3.72	2.80	3.95	3.37	4.53	3.43	4.32	4.00	4.30	4.11
Concord	3.83	3.55	2.79	2.14	2.88	3.03	3.67	2.98	3.74	3.16	3.12	3.41
Hanover	†2.84	†2.55	†1.84	†1.30	†2.70	‡2.90	‡3.38	†2.87	†2.49	†2.48	†3.27	†2.47
Weir's Bridge	3.84	3.73	2.89	2.32	3.14	3.18	4.01	3.17	3.94	3.40	3.68	3.90
	3.78	3.52	2.81	2.14	3.17	3.12	3.90	3.11	3.62	3.26	3.59	3.47
Vermont:												
Burlington	1.68	1.48	1,78	1.67	2.86	2.98	2.82	3.08	3.64	3.12	2.88	1.85
Lunenburg	2.99	2.49	2.33	1.15	3.14	3.35	3.60	3.25	3.41	3.76	3.10	2.82
Strafford	3.64	3.16	3.14	1.90	3.06	2.95	4.52	3.61	3.70	3.02	3.92	3.28
Woodstock	*3.00	*2.77	*2.68	§1.66	§3.16	§2.24	*3.98	*3.00	‖3.41	*2.68	*2.09	*3.27
	2.83	2.48	2.48	1.60	3.06	2.88	3.73	3.24	3.54	3.14	3.00	2.80
Massachusetts:												
Amherst	4.23	3.72	3.62	2.53	3.59	3.45	4.69	4.08	4.50	3.40	3.77	3.67
Boston	4.81	3.99	3.64	2.73	3.86	2.81	3.51	3.58	3.30	3.62	3.38	3.27
Fitchburgh	4.61	3.56	2.66	2.56	3.14	2.79	4.05	3.85	3.74	3.24	3.31	3.31
Lawrence	*5.44	*4.28	*3.91	*2.75	§3.30	§2.84	§4.18	§4.87	§3.59	§3.77	§4.69	§3.58
New Bedford	4.78	4.76	3.99	3.45	3.61	3.07	4.00	4.08	3.45	3.56	3.97	3.93
Springfield	†4.44	†4.36	†3.23	†2.65	†3.48	†3.80	†4.97	†4.09	†3.52	†3.62	†3.72	†3.84
Williamstown	†3.34	†3.25	3.10	†2.60	3.02	2.98	†4.61	†3.72	3.05	2.62	3.24	†3.40
Worcester	‡4.56	‡4.42	‡3.49	‡2.67	†4.13	‡3.63	‡3.38	‡3.33	†3.84	†3.85	†3.96	†4.06
	4.53	4.04	3.46	2.74	3.52	3.17	4.17	3.95	3.62	3.46	3.76	3.63

* For seven days. † For nine days. ‡ For eight days. § For six years. ‖ For five years.

Table showing the average precipitation, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Rhode Island:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Narragansett Pier	*5.84	*4.95	*4.28	‡3.27	‡2.88	‡2.69	‡3.89	‡3.99	‡3.40	‡4.46	‡4.32	‡3.78
Providence	†6.19	†6.30	†4.33	†3.22	†3.67	†2.99	‡4.07	†4.06	†3.29	†4.10	†4.11	†4.59
	6.02	5.62	4.30	3.24	3.28	2.84	3.98	4.02	3.34	4.28	4.22	4.18
Connecticut:												
Hartford	5.10	4.39	3.49	2.53	3.37	2.61	5.02	4.01	3.49	3.97	3.88	4.19
Middletown	3.52	4.95	4.27	2.70	3.17	3.30	5.02	3.59	4.17	4.25	4.02	4.38
New Haven	4.44	4.56	4.30	2.64	3.84	3.14	5.37	4.67	4.04	3.97	3.48	3.97
New London	5.25	5.41	4.46	3.36	3.94	3.47	4.04	4.55	3.77	4.72	4.40	3.77
	4.58	4.83	4.13	2.41	3.58	3.13	4.86	4.20	3.87	4.23	3.94	4.08
Northern New York:												
Albany	2.95	2.56	2.72	2.24	3.13	3.58	3.68	3.67	3.28	3.18	3.46	2.94
Oswego	3.18	2.93	2.49	1.99	3.02	3.61	2.60	2.41	2.66	2.92	3.47	3.66
Rochester	2.61	2.35	2.35	2.16	3.61	3.37	2.30	3.10	2.10	2.63	2.53	2.44
	2.91	2.61	2.52	2.13	3.25	3.52	2.86	3.06	2.68	2.91	3.15	3.01
Northwestern Pennsylvania:												
Erie	3.38	3.79	2.58	2.76	3.46	4.29	2.73	3.29	3.71	4.06	4.46	3.47
Franklin	3.90	3.38	2.52	2.41	3.50	6.12	4.04	3.54	3.27	2.89	2.94	3.25
	3.64	3.58	2.55	2.58	3.48	5.20	3.38	3.42	3.49	2.48	3.70	3.36
Northern Ohio:												
Cleveland	2.44	3.37	2.34	2.20	2.52	4.03	3.47	2.53	3.38	2.56	3.07	2.54
Sandusky	2.14	3.18	2.38	2.34	3.64	4.29	3.08	3.37	2.59	2.51	2.72	2.54
Toledo	2.14	2.55	1.95	1.98	3.78	3.67	3.29	2.44	2.54	2.92	2.74	2.30
Wauseon	2.40	3.17	2.47	2.43	4.58	3.90	3.51	2.65	2.12	3.14	3.26	2.55
	2.28	3.07	2.28	2.24	3.63	3.97	3.34	2.75	2.66	2.78	2.95	2.48
Northern Indiana:												
Logansport	2.14	4.24	2.59	3.04	5.29	5.15	3.71	2.76	3.08	3.03	3.55	3.44
Michigan:												
Adrian	2.25	§3.48	§2.47	2.60	4.44	4.90	3.81	3.24	3.38	3.79	3.44	2.70
Alpena	3.08	2.61	2.27	2.23	3.81	4.21	3.07	3.24	3.57	3.71	3.16	2.90
Escanaba	2.04	1.68	1.59	2.06	3.17	3.84	2.74	3.64	4.16	3.51	2.26	2.44
Grand Haven	2.78	3.21	2.38	2.45	3.21	4.04	3.57	3.23	3.50	3.75	2.75	3.14
Kalamazoo	2.46	2.96	1.87	2.24	4.36	4.96	2.93	2.52	3.06	2.84	2.39	2.93
Lansing	1.96	2.68	2.55	2.24	3.92	4.43	3.17	2.90	3.14	3.21	2.66	1.80
Marquette	3.28	§1.88	1.74	2.68	2.71	3.24	2.74	3.27	4.27	3.06	2.72	2.96
Port Huron	2.34	2.97	2.40	2.00	3.43	3.60	2.62	2.44	2.16	2.76	2.63	2.26
	2.52	2.68	2.16	2.31	3.63	4.15	3.08	3.06	3.40	3.33	2.75	2.64
Northern Illinois:												
Chicago	2.22	3.03	2.19	3.08	3.83	3.53	3.86	3.42	2.88	3.65	2.82	2.42
Riley	2.28	2.66	2.37	2.61	3.25	3.64	3.18	3.44	3.16	3.14	2.00	2.05
Sycamore	‖2.12	‖2.40	‖2.10	‖3.70	§4.06	§4.78	§4.68	§3.47	§3.23	§4.21	§2.56	§2.59
	2.21	2.70	2.22	3.13	3.71	3.98	3.91	3.44	3.09	3.67	2.46	2.35
Iowa:												
Cresco	1.47	1.11	1.64	2.27	3.73	§4.53	§5.19	§3.52	§4.26	2.29	1.28	1.50
Davenport	1.55	1.91	2.14	2.38	4.42	4.47	3.85	3.64	3.41	3.75	1.88	1.92
Des Moines	1.31	1.29	1.40	2.94	5.30	5.88	4.02	3.74	3.95	3.66	1.77	1.54
Dubuque	1.83	1.84	2.23	2.73	4.12	4.74	4.66	3.39	4.47	3.22	1.75	2.11
Logan	‖1.86	1.26	1.42	3.05	4.49	5.82	5.22	3.93	3.00	2.94	§1.44	‖1.32
	1.60	1.48	1.77	2.67	4.41	5.09	4.59	3.64	3.82	3.17	1.62	1.68
Wisconsin:												
Embarrass	2.96	2.65	2.27	2.92	4.45	5.71	5.15	5.58	5.05	4.17	2.94	3.14
La Crosse	1.31	0.99	1.45	2.10	2.80	3.57	5.00	3.85	4.71	2.15	1.32	1.32
Madison	2.08	2.30	2.54	2.92	3.56	4.64	5.36	3.76	3.71	3.28	1.76	2.55
Milwaukee	1.96	2.36	2.16	2.18	2.78	3.95	3.80	2.68	2.71	2.24	1.60	2.22
	2.08	2.08	2.10	2.53	3.40	4.47	4.83	3.97	4.04	2.98	1.90	2.31

* For seven days. † For nine days. ‡ For eight days. § For nine years. ‖ For eight years.

Table showing the average precipitation, etc.--Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Minnesota:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In*	*In.*	*In.*	*In.*	*In.*
Duluth	1.26	.34	1.35	2.44	3.50	4.52	3.32	4.14	3.90	3.14	1.76	1.33
Moorhead	*0 82	*0.86	*0.76	*2.18	*2.75	*3.84	*4.37	*2.70	*2.40	*2 25	*0.93	*0.83
St. Paul	1.21	1.00	1.21	2.69	2.58	3.55	3.53	2.99	3.24	1.64	1.22	1.33
	1.10	1.07	1.11	2.44	2.98	3.97	3.74	3.28	[illegible]	2.31	1.30	1.16
North Dakota:												
Bismarck	0.52	0.61	0.67	1.86	2.11	2.98	2.68	1.98	0.88	1.04	0.52	0.75
Fort Buford	0:66	0.43	0.42	1.11	1.51	3.07	1.96	1.55	0.84	0.80	0.35	0.56
Fort Totten	0.48	0.59	0.38	1.21	2.11	3.84	2.62	2.66	0.80	1.49	1.02	0 75
St. Vincent, Minn	*0.48	*0.50	*0.53	*1.26	*2.00	*3.01	*2.70	*2.28	1.93	1.76	0.56	0.71
	0.54	0.53	0.50	1.37	1.93	3.22	2.49	2.12	1.11	1.27	0.61	0.69
South Dakota:												
Deadwood, Rapid City	1.25	1.34	1.78	3.98	4.19	3.66	2.70	2.31	0.86	1.06	1.24	1.12
Fort Sisseton, Wadsworth.	0.39	*0.37	*0.87	*1.78	*2.33	*3.50	*3.16	*3.38	*1.30	*1.81	†0.56	*0 52
Fort Sully	0.51	0.43	0.53	1.84	2.10	3.16	2.67	2.23	0.82	0.52	0.36	0.49
Yankton	0.59	0.77	1.05	3.35	4.83	3.14	3.16	3.30	3.17	1.66	0.84	0.87
	0.68	0.73	1.06	2.74	3.36	3.36	2 92	2.80	1.54	1.26	0.75	0.75
Nebraska:												
De Soto	1.00	0.86	1.55	2.29	3.64	4.71	3.86	3.55	2.56	2.45	0.89	1.10
Genoa	0.98	0.67	1.03	2 85	3.96	4.21	4.57	2.86	3.29	1 68	0.66	0.86
North Platte	0.34	0 38	0.70	2.03	3.30	3.58	2.76	2.72	1.57	1.37	0.37	0.55
Omaha	0.82	0.91	[illegible]	[illegible]	4.64	5.76	5.26	3.55	3.06	2.97	0.92	0.94
	0.77	0.70	1.15	2.52	3.88	4.56	4.11	3.17	2.62	2.12	0.71	0.86
California:												
Benicia Barracks	2.87	*2.06	*2.75	2.62	0.70	0.30	Trace	Trace	0.25	†1.33	*2.10	4.60
Fort Bidwell	3.51	2.46	2.03	*2.31	†1.11	†1.13	*0.32	*0.09	*0.27	*1.66	1.90	*3.47
Fort Gaston	9.99	6.45	4.30	5.69	2.60	0.96	0.10	*0.04	*0.88	*3.55	4.76	10.68
Los Angeles	2.39	3.38	3.35	1.92	0.41	0.16	0.04	0.06	0.07	1.07	1.67	4.29
Red Bluff	3.05	2.04	2.80	2.54	1.00	0.65	0.01	0.00	0.63	1.83	3.33	5.44
Sacramento	3.15	2.28	3.17	3.01	0.77	0.25	0.00	0.00	0.03	1.29	2.52	4.96
San Diego	1.91	2.38	2.05	1.19	0.50	0.09	0.01	0.05	0.02	0.63	0.76	2.40
	3.82	[illegible]	2.92	2.75	[illegible]	0.51	0.07	0.03	0.31	1.62	2.43	5.12
Oregon:												
Albany	7.92	5.70	3.67	3.51	2.27	1.71	0 60	0.40	1.78	3.76	3.98	8.76
Eola	7.16	4.73	3.27	2.73	1.84	1.39	5.48	5.22	1.84	3.40	3.59	7.06
Fort Klamath	3.62	2.44	*1.42	1.52	1.35	‡1.49	5.70	1.14	4.73	†1.68	*1.99	*4.19
Portland	7.28	4.97	3.72	3.66	2.48	1.71	0 61	0.56	1.93	4.31	5.01	9.56
Roseburg	6.06	3.92	2.30	2.87	1.55	1.48	0.51	0.15	*0.58	3.01	3.18	6.78
	6.41	4.35	2.88	2.86	1.90	1.56	2.58	1.49	2 17	3.25	3.55	7.27
Washington:												
Blakeley	6.25	4.32	4.02	2.81	2.05	1.48	0.83	0.80	2.15	3.73	4.22	7.86
Fort Canby	8.08	7.15	5.94	4.63	3.06	2.37	1.26	0 87	3.35	6.26	6.96	9.84
Olympia	8.68	5.78	4.14	3.83	2.50	1.70	0.71	0.56	2.54	4.31	4.97	9.09
Port Townsend	2.71	1.46	1.33	1.73	1.43	1.28	0.98	0.74	0.90	1.93	2.17	3.08
	6.43	4.68	3.86	3.25	2.26	1.71	0.94	0.74	2.24	4.06	4.58	7.47

* For nine years. † For eight years. ‡ For seven years.

Table showing the mean temperature in degrees F. for each month of the year at the stations specified. (Deduced from observations during the period, January, 1880, to December, 1889, inclusive.

State and station.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maine:	°	°	°	°	°	°	°	°	°	°	°	°
Cornish	18.1	20.4	27.6	41.4	55.3	65.3	68.6	66.5	58.5	45.7	34.7	24.4
Eastport	20.4	21.9	28.1	38.4	47.3	55.8	60.5	60.4	55.8	46.3	37.4	26.5
Gardiner	17.9	20.6	26.7	41.0	53.5	*62.0	67.2	65.0	58.3	46.5	36.8	25.6
Orono	15.4	18.8	27.0	40.0	52.0	62.5	67.0	65.0	57.3	45.1	35.2	23.6
Portland	23.0	25.1	32.0	44.8	54.3	63.9	68.4	72.7	59.9	48.8	39.4	29.2
	19.0	21.4	28.3	41.1	52.5	61.9	66.3	65.9	58.0	46.5	36.7	25.9
New Hampshire:												
Concord	21.5	24.5	30.8	45.3	57.2	65.3	69.4	67.1	60.3	49.0	38.7	28.2
Hanover*	*17.5	18.8	26.6	40.6	56.5	64.1	69.3	65.6	58.2	45.6	33.8	22.4
	19.5	21.6	28.7	43.0	56.8	64.7	69.4	66.4	59.2	47.3	36.2	25.3
Vermont:												
Burlington	18.7	20.6	27.5	42.8	58.6	66.6	71.0	69.2	61.6	47.6	37.1	25.6
Lunenburg	14.5	16.8	24.0	38.8	55.4	63.3	67.3	65.1	57.9	44.2	33.2	21.5
Strafford	15.1	17.6	25.1	41.3	57.1	63.9	69.5	67.5	59.3	46.3	34.8	22.4
Woodstock	12.8	18.1	25.3	40.4	55.7	64.7	68.8	65.3	58.2	45.1	32.6	21.3
	15.3	18.3	25.5	40.8	56.7	64.6	69.2	66.8	59.2	45.8	34.4	22.7
Massachusetts:												
Amherst	23.3	25.0	32.1	46.2	57.9	66.6	70.7	68.0	61.4	49.0	39.5	29.6
Boston	26.7	28.1	33.3	44.6	55.7	65.9	70.3	68.5	62.2	50.8	41.8	32.2
Fitchburg	21.9	23.6	29.0	42.8	56.4	65.8	69.7	66.8	60.2	47.3	37.1	27.6
Lawrence	‡22.7	‡22.7	‡31.0	‡45.2	‡58.8	‡67.2	‡72.0	‡67.2	‡59.8	‡48.0	‖38.4	§27.6
New Bedford	27.5	28.4	33.1	43.9	54.1	64.1	69.2	67.3	60.1	51.0	42.6	31.8
Springfield	24.0	25.9	32.5	46.8	60.5	68.8	72.8	68.9	63.3	50.4	40.0	*30.0
Williamstown	20.2	22.6	28.2	42.7	56.8	64.6	68.2	64.6	58.7	47.0	37.1	26.6
Worcester	23.4	23.9	30.0	†42.8	†55.2	*65.1	*70.0	66.8	*60.7	*48.0	38.7	28.6
	23.7	25.0	31.2	44.4	57.0	66.0	70.4	67.3	60.8	48.9	39.4	29.2
Rhode Island:												
Providence	‡25.3	‡28.5	‡32.2	‡45.4	‡56.5	‡67.6	§73.1	‡69.8	‡62.1	‡51.2	‡41.9	‡31.1
Connecticut:												
Hartford	§22.4	§24.0	§30.3	§46.7	§59.4	§67.2	§72.2	§68.2	‖60.7	‡48.6	†39.8	‡29.2
Middletown	‖24.3	‖23.9	§31.4	‖46.4	‖58.7	‖65.9	‖70.5	‖67.2	§55.5	‖48.4	§40.4	§31.0
New Haven	26.5	28.1	33.5	45.7	57.3	66.3	71.0	69.0	63.3	51.7	41.6	32.0
New London	28.9	30.0	35.0	46.0	56.6	65.6	70.5	69.1	63.7	53.0	43.4	34.0
	25.5	26.5	32.6	46.2	58.0	66.2	71.0	68.4	60.8	50.4	41.3	31.6
Northern New York:												
Albany	23.4	25.6	32.1	47.1	60.7	69.0	73.1	70.7	63.8	51.1	40.7	30.0
Oswego	23.3	24.3	28.8	41.5	54.5	62.6	68.4	67.1	61.3	49.0	39.1	29.4
Rochester	23.1	24.0	28.8	42.7	56.6	*62.5	*69.5	*67.4	*62.2	48.7	38.2	29.1
	23.3	24.6	29.9	43.8	57.3	64.7	70.3	68.4	62.4	49.6	39.3	29.5
Northwestern Pennsylvania:												
Erie	26.1	27.2	31.3	43.8	57.2	65.8	70.6	68.7	63.2	51.8	40.9	32.5
Franklin	21.8	23.9	29.1	43.7	56.0	60.2	65.5	62.5	56.8	45.3	34.2	26.2
	24.0	25.5	30.2	43.8	56.6	63.0	68.0	65.6	60.0	48.6	37.6	29.4
Northern Ohio:												
Cleveland	25.3	27.8	32.5	45.1	58.8	66.7	71.1	69.0	63.8	52.1	40.1	31.4
Sandusky	25.8	28.4	33.6	45.4	*59.5	*67.0	*72.9	70.7	64.9	52.5	40.5	31.8
Toledo	25.2	27.9	34.2	46.8	59.8	68.5	73.2	70.2	64.1	52.1	40.3	31.3
Wauseon	21.4	24.9	31.8	46.0	58.5	67.2	71.9	68.9	62.9	49.8	36.9	27.7
	24.4	27.2	33.0	45.6	59.2	67.4	72.3	69.7	63.9	51.6	39.4	30.6
Northern Indiana:												
Logansport	*24.0	†29.9	†36.7	*52.9	*64.7	*71.2	*76.2	*73.9	†67.2	‡55.3	*40.0	*30.7

* For nine years. † For eight years. ‡ For seven years. § For six years. ‖ For five years.

Table showing the mean temperature in degrees F. for each month, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Michigan:	°	°	°	°	°	°	°	°	°	°	°	°
Adrian	20.3	*25.9	*31.0	45.2	58.4	67.2	71.6	68.4	61.7	49.1	36.6	28.2
Alpena	16.9	16.7	22.9	36.4	49.0	59.0	64.7	63.0	56.7	44.7	33.2	25.0
Escanaba	13.6	20.2	21.2	32.6	45.1	54.4	59.5	57.1	51.2	40.4	28.2	20.1
Grand Haven	23.3	24.2	30.0	43.4	54.7	63.2	68.2	66.3	59.2	49.2	38.0	30.0
Kalamazoo	20.6	23.7	30.3	46.2	57.6	67.1	72.3	69.1	62.4	50.4	36.5	28.1
Lansing	21.1	23.4	30.5	45.8	58.6	68.3	72.7	69.8	62.7	44.8	32.9	22.8
Marquette	14.5	*15.5	21.8	36.6	49.1	57.6	64.2	62.3	56.1	44.5	31.9	23.8
Port Huron	19.2	21.7	28.1	41.5	53.1	63.3	68.3	67.0	60.6	48.8	35.7	26.9
	18.7	21.7	27.0	41.0	52.4	62.5	67.7	65.4	58.8	46.5	34.2	25.6
Northern Illinois:												
Chicago	22.4	26.3	34.1	46.0	56.4	65.4	71.4	70.6	64.2	52.5	39.2	30.2
Riley	14.6	19.5	29.1	45.6	56.1	65.7	70.3	67.9	60.2	47.9	33.3	23.1
Sycamore	†15.3	†21.0	‡30.4	‡46.0	*54.5	*66.8	*71.2	*68.6	*59.9	*48.7	*35.5	*26.2
	17.4	22.3	31.2	45.9	55.7	66.0	71.0	69.0	61.4	49.7	36.0	26.5
Iowa:												
Cresco	7.4	13.6	26.7	44.4	56.2	*66.2	*70.4	*68.1	*58.6	45.8	29.0	18.3
Davenport	19.4	24.9	35.0	50.1	61.2	69.7	74.8	72.2	64.4	52.2	38.2	28.3
Des Moines	16.6	23.1	34.7	50.2	60.9	69.8	74.5	72.1	63.5	51.7	36.6	26.5
Dubuque	16.1	21.7	32.7	48.6	60.1	68.5	73.6	70.9	63.6	50.4	35.7	25.6
Logan	16.5	22.4	35.2	51.7	63.2	71.6	75.9	74.0	65.9	52.4	36.1	26.1
	15.2	21.1	32.9	49.0	60.3	69.2	74.6	71.5	63.2	50.5	35.1	25.0
Wisconsin:												
Embarrass	11.2	15.5	26.4	44.2	59.1	68.0	71.0	68.2	60.9	48.5	32.4	21.2
La Crosse	13.4	19.1	30.5	47.3	59.8	68.5	72.7	69.8	61.4	49.5	34.3	23.8
Milwaukee	17.9	21.9	30.3	42.4	53.3	61.7	68.4	67.4	60.7	49.7	36.0	26.4
	14.2	18.8	29.1	44.6	57.4	66.1	70.7	68.5	61.0	49.2	34.2	23.8
Minnesota:												
Duluth	7.9	12.4	23.2	37.5	48.1	57.3	65.2	63.6	55.2	44.4	29.5	17.8
Moorhead	2.9	2.9	20.0	40.2	53.6	64.5	67.6	65.1	55.3	39.0	24.9	11.1
St. Paul	9.1	14.9	27.9	45.3	57.8	66.9	71.3	68.6	60.0	47.2	31.0	19.4
	4.7	10.1	23.7	41.0	53.2	62.9	68.0	65.8	56.8	43.5	28.5	16.1
North Dakota:												
Bismarck	3.2	9.2	23.0	41.4	54.9	65.0	69.1	67.0	56.3	43.7	26.6	13.8
Fort Buford	2.6	9.3	24.0	41.7	53.9	64.2	68.0	66.1	54.8	42.6	25.8	10.8
St. Vincent, Minn	*7.5	*0.6	*15.3	*36.6	*51.7	*62.3	*65.0	*62.5	52.6	40.0	21.2	6.2
Fort Totten	*4.5	3.8	17.1	37.7	53.8	64.0	67.3	65.7	55.0	41.3	22.5	8.2
	1.6	5.7	19.8	39.4	53.8	63.9	67.4	65.3	54.7	41.9	24.0	9.8
South Dakota:												
Fort Sisseton	0.4	6.0	21.0	*40.9	*55.2	*65.0	*69.0	*65.1	*56.8	*43.0	*25.4	*11.2
Fort Sully	8.8	15.5	29.6	47.5	58.9	68.9	73.9	72.1	61.9	48.2	30.7	19.1
Deadwood	19.4	22.9	31.3	41.3	50.4	61.1	66.0	65.4	55.2	44.5	32.4	26.0
Yankton	12.6	18.2	30.6	47.0	59.3	69.2	73.5	71.3	61.8	49.6	33.0	22.4
	10.3	15.6	28.1	44.2	56.0	66.0	70.6	68.5	58.9	46.3	30.4	19.7
Nebraska:												
De Soto	14.5	21.5	34.0	50.7	61.5	70.5	74.9	72.6	63.5	51.1	34.4	24.4
Geneva	13.5	20.4	32.3	48.6	60.4	70.0	74.6	72.3	62.8	49.8	33.0	23.4
North Platte	18.6	25.1	35.1	48.5	58.1	68.3	73.2	71.1	62.0	49.6	34.5	27.0
Omaha	16.6	23.4	35.1	51.1	62.2	71.4	76.2	74.4	64.8	52.0	37.0	26.7
	15.8	22.6	34.1	49.7	60.6	70.0	74.7	72.6	63.3	50.6	34.7	25.1
California:												
Benecia Barracks	46.6	*49.6	*54.2	56.9	61.4	65.6	65.8	68.4	*66.6	61.7	54.2	50.3
Fort Bidwell	31.4	33.8	41.4	47.9	*55.9	*63.5	71.0	70.7	62.6	51.2	40.4	35.8
Fort Gaston	41.0	43.7	49.8	†53.8	59.8	65.0	71.8	69.3	63.7	54.5	46.0	44.2
Los Angeles	53.6	54.4	56.2	59.0	62.2	65.9	69.4	70.6	68.7	63.1	58.7	55.5
Red Bluff	45.5	49.1	55.2	59.8	67.5	75.2	82.1	80.5	*74.7	62.7	*52.7	47.5
Sacramento	45.5	49.4	54.7	58.2	63.4	68.2	71.9	71.8	69.6	61.0	52.4	47.5
San Diego	53.5	54.7	56.1	58.8	61.5	64.4	67.2	69.1	67.2	62.6	53.3	56.3
	45.3	47.8	52.5	56.3	61.7	66.8	71.3	71.5	67.6	59.5	51.1	48.2

* For nine years. † For eight years. ‡ For seven years.

Table showing the mean temperature in degrees F. for each month, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
Oregon:												
Albany	38.6	40.9	47.5	51.8	57.9	61.0	66.3	65.4	62.1	*49.0	43.2	41.8
Eola	37.6	39.8	46.8	50.1	55.8	60.3	60.7	64.4	59.1	51.6	43.7	41.5
Fort Klamath	†26.4	†26.8	‡34.7	†40.0	†49.7	‡56.9	†61.6	†62.1	†51.7	§41.5	†33.2	†30.4
Portland	37.0	40.0	47.6	51.8	58.0	62.1	66.4	65.3	60.6	53.0	44.8	41.6
Roseburg	40.4	41.6	47.5	51.6	57.1	61.4	66.5	65.0	61.4	52.2	44.5	43.2
	36.0	37.8	44.8	49.1	55.7	60.3	64.3	64.4	59.0	49.5	41.9	39.7
Washington:												
Blakeley	38.5	40.3	46.1	50.8	56.0	61.2	63.3	62.7	57.6	51.0	45.1	41.8
Fort Canby	41.0	41.7	46.0	49.0	53.2	56.5	59.0	59.5	57.8	53.0	47.1	44.1
Olympia	37.6	39.0	44.5	48.7	54.5	59.2	62.3	61.9	56.2	50.1	43.8	40.6
Port Townsend	*38.7	*39.3	†46.2	51.3	55.0	60.0	62.0	61.2	†56.4	*53.4	*44.0	*40.9
	39.0	40.1	45.7	50.0	54.7	59.2	61.6	61.3	57.0	51.9	45.0	41.8

*For nine years. †For eight years. ‡For six years. §For seven years.

Dr. McMurtrie, in special report No. 28, has made a careful study of the climatic conditions in the United States favorable to the production of the sugar beet. Maps are given showing the southern limit of a mean temperature of 70° Fah. for the three summer months, coupled with a minimum mean rain-fall of two inches per month for the same period. The tables of temperature and rain-fall, from which these lines were computed, are also given in detail. The observations made on the data collated are as follows:

"We see from this that the sections of the United States most favorable to beet-root culture are confined to the north, including New England, New York, a narrow band south of the lakes, Michigan, parts of Wisconsin, Minnesota, and Dakota. Here the line of the southern limit passes into the British possessions and enters the United States again in Washington Territory, and, crossing Western Oregon, passes to the coast to the extreme north of California. In most of this band we find a favorable temperature, and the average rain-fall is sufficient in quantity, but we are unable to make any observations concerning the number of rainy days. In California, as the tables will show, the temperature is sufficiently moderate, but, from examination of the figures for the stations for which the rain-fall has been recorded, we find it to be remarkably deficient. Here, in order to make the culture a success, it would appear that the intervention of irrigation during the summer months would be an absolute necessity.

"We also note a few counties in the southwestern portion of Pennsylvania, and one county in Ohio, without the general band, where suitable meteorological conditions seem to exist. These counties are surrounded by the red line in the more detailed map that has been prepared, showing the county lines near to or over which the line of the limit of favorable meteorological conditions passes. This map is intended for more ready reference for those who may contemplate establishing the culture in the sections in the near neighborhood of the line.

"Now, I do not mean to assert that the band of country I have thus plotted on the map is exclusively that in which the introduction of beet-root culture may be attempted with prospects of success, but it is certain that within this band the chances of success are greater than they are without it, and it also appears that all the unsuccessful attempts that have heretofore been made to establish the industry have been at points without it. It is therefore advisable that farmers or manufacturers who may design entering upon the prosecution of this industry should study with greatest care these influences which operate with so much benefit or injury upon the profit of the crop. It is evident from what precedes that the beet requires a cool or at least a moderate season for suitable progress in development, that it may not reach maturity in advance of the time for working it into sugar, and under the influence of the rains and elevated temperature of the autumn months enter into a second growth, thereby destroying the valuable constituents which renders it so desirable as a sugar-producing crop.

"In this connection it has been suggested that in sections of protracted warm seasons, when the root will develop and attain full maturity in August, and during the summer drought, the crop could be taken up before the appearance of the autumn rains, and by slicing and drying the roots preserve them until the arrival of the proper season. This mode of procedure has in fact been recommended to the agriculturists of the south of France, and has, it has been stated, been the subject of experiment in Algeria. The method has the objection of being a rather precarious one on account of the chances of the crop being caught after a long-continued drought by late heavy summer showers that would prove almost as injurious as the autumn rains.*

"After the directions given by Briem and others it is scarcely necessary to recapitulate here the meteorological conditions which appear to be required by this culture, yet the conclusions arrived at from our study of the subject, in addition, may not appear superfluous. The conditions, then, are in general, comparatively dry and warm spring months during the time for preparation of the soil, planting, and cultivating the crop; moderate temperature, abundant and frequent rains during the summer months, the time for ultimate development of the crop and its valuable constituents; cool dry fall, the time for ripening, harvesting, and storing the crop. If these conditions prevail, the results will be good; otherwise they will be but medium or even bad."

The amount of rain-fall necessary to the proper growth of sugar-beets depends largely on the character of the soil, the mean temperature, and the degree of saturation with aqueous vapor of the prevailing winds. In the coast valleys of California, where the proximity of the sea preserves a low temperature through the summer, and where the porous soil permits the tap root of the beet to descend after moisture and moisture to

* The experiment of drying beets for preservation in Maine, in the fall of 1878, proved quite disastrous financially for those who engaged in the enterprise.

ascend to the root, excellent beets are grown with little rain. The conditions would be entirely reversed in inland localities with high summer heats, stiff clayey soils, and arid winds.

In general, the amount of rain-fall during the summer months in the Northern, Central, and Eastern United States is sufficient to secure a good growth, and therefore it may be said that proper soil and locality being provided, beet culture might be undertaken in such localities with little fear of disaster from drought, save in a few exceptional seasons.

In fact, with thorough under drainage and deep subsoil plowing, it would be possible to secure a good crop of beets in the regions indicated quite independently of the variation in the amount of rain-fall.

The chief question, therefore, to be considered, is one of temperature rather than of rain-fall. In the present state of our knowledge it would not be safe to establish beet factories very far south of the mean isotherm of 70° Fahr. for the three summer months, without a more thorough study of the character of the beets produced than has heretofore been made. The possibility of finding localities south of this line, where sugar-beets may be grown with profit, is not denied, but the necessity of further investigation is urgent. There are many places situated only a short distance south of this line where the soil, water supply, cheap fuel, and other local considerations supply peculiarly favorable conditions for beet culture, and in such places the industry would doubtless flourish, although the beet might not be quite as rich in sugar as when grown in a more northern locality. In all cases the length of the growing season should be sufficient for the complete maturity of the beet, and the freezing temperatures of winter should come sufficiently late to allow the beets to be safely harvested and covered. The shaded belt of the map, Plate 2, indicates fairly well those portions of the United States in which areas suited to successful beet culture are most likely to be found.

RECENT EXPERIMENTS LOOKING TO THE INTRODUCTION OF THE BEET-SUGAR INDUSTRY.

EXPERIMENTS IN INDIANA.

Sugar beets have been grown for two seasons at the Agricultural Station at La Fayette, viz, 1888–'89. The experiments for 1889 were conducted as follows:

The seeding took place on the 29th of April in rows 3 feet apart, and the plants were thinned so they stood from 4 to 6 inches apart in the rows. No information is given concerning the method of preparing the land and no note is made of any fertilizers used. The beets were harvested on the 23d and 25th of October. Analyses were made by the chemist of the station, Professor Huston, and a comparison of the yield per acre and the percentage of sugar found in each variety is found in the following table:

Variety.	1888.		1889.	
	Yield per acre.	Sugar.	Yield per acre.	Sugar.
	Tons.	*Per cent.*	*Tons.*	*Per cent.*
White sugar	14.48	11.35	13.59	13.05
Imperial sugar	14.48	11.67	15.60	12.80
Vilmorin's sugar	12.08	9.92	13.20	12.85
French yellow sugar	12.07	11.64	15.99	9.20
Lane's imperial sugar	8.74	16.40	16.80	10.40

The mean temperature for June, July, and August, 1889, was 69.2° Fah., which is about 3 degrees below the average of this period for ten years.

EXPERIMENTS IN MICHIGAN.

Analyses of sugar beets grown in Michigan in 1889.—There are no details given of the method of planting and cultivating the beets or the time of planting and harvesting. The following data were furnished by Dr. R. C. Kedzie, Chemist of the Agricultural Experiment Station, in a letter under date of October 5, 1889:

No.	Variety.	Sucrose.
		Per cent.
1	Vilmorin Imperial, imported seed	14.58
2	Beets grown on Senator Palmer's farm without manure	11.40
3	Beets grown on Senator Palmer's farm with 200 pounds superphosphates and 200 pounds nitrate of soda per acre	11.40
4	Beets grown on Mr. Klein's farm, Oakland County	12.87
5	Beets grown in Livingston County	7.86
6	Beets grown by George C. Anschuetz, Tawas City, imported seed	12.78
7	Beets grown by George C. Anschuetz, Tawas City, American seed	13.40

EXPERIMENTS IN WISCONSIN.

Under authority of the Secretary of Agriculture I made arrangements with Prof. W. A. Henry, director of the Wisconsin Agricultural Experiment Station, for culture experiments with the sugar beet.

The interesting and instructive report of Professor Henry follows.

The remarkably favorable weather during October is a factor in the production of sugar beets which should not go unnoted. Only a trace of rain fell at Madison in October, and the season for harvesting and siloing could not have been better.

The general results are encouraging, sufficiently so to justify further cultural work, a kind of work which may eventually result in the establishment of factories.

REPORT ON INVESTIGATION OF BEETS FOR SUGAR PRODUCTION IN 1889, AT THE WISCONSIN AGRICULTURAL EXPERIMENT STATION, UNDER DIRECTION OF THE DEPARTMENT OF AGRICULTURE, WASHINGTON.

Varieties and planting.—Three varieties of seed were furnished by the Department, one, not named, being received from the California Beet Sugar Company; the other two, viz, Vilmorin's Improved and Lane's Imperial were received directly from Washington. The seed from California arrived in April, and was planted May 5. The other varieties, for some reason, did not reach Madison until June, and were planted June 6, too late to give entirely satisfactory results as the season after this time was exceptionally dry, causing the beets to grow slowly.

The beets were planted in rows 3 feet apart and were thinned to about 8 inches apart in the rows. They were carefully cultivated, the soil being kept free from weeds, and in good tilth throughout the season.

Meteorology.—The season of 1889 was most remarkable for the very small rain-fall, not one-half the average amount of precipitation being registered for the growing season.

May, June, and October were somewhat cooler than the average, while July and August were slightly warmer.

TABLE I.—*Showing temperature and rain-fall.*

	Rain-fall.		Temperature.			
	1889.	Mean for thirty-three years.	Mean for 1889.	Mean for thirty-three years.	Highest 1889.	Lowest 1889.
	Inches.	*Inches.*	° *F.*	° *F.*	° *F.*	° *F.*
May	3.28	3.6	56.1	57.9	82	34.2
June	2	4.7	63.4	67.2	83.3	42.2
July	2.12	4.31	74.3	72.6	91.6	54.7
August	.72	3.49	70	69.5	90.5	51
September	1.93	3.37	61.18	61.2	90.2	34.8
October	trace.	3.04	46.1	48.8	75.5	29

Development of the sugar in the beet root.—The first analyses were made September 20, and after this date beets from each lot were frequently examined until they were harvested to protect them from the frost on October 22.

The following table gives the per cent. of sugar in the juice from each variety at the dates when examined. The determinations were made with the polariscope.

TABLE II.—*Showing per cent. of sugar in juice of beets at different periods.*

Vilmorin's Improved.		Lane's Imperial.		California Beet Sugar Company.	
Date.	Per cent.	Date.	Per cent.	Date.	Per cent.
September 20	8.07	September 20	7.97	September 20	8.074
September 22	10.35	October 11	14.40	October 4	9.68
October 9	10.60	October 19	15.60	October 7	10.05
October 14	11.95			October 15	11.54
October 17	15.60			October 22	14.50

Grading the beets.—The beets were harvested October 22, at which time they were divided into two grades, the classification being based upon the shape and manner of growth. The first grade represents those roots that were comparatively smooth and conical in shape. The beets of the second class were irregular in shape, with large, scraggly roots.

This second type of beets was not scattered uniformly through the plot, but grew in patches of three, four, or a dozen together. indicating that some local peculiarity of the soil or treatment was the cause of their irregular development.

Abnormal beets.—A few beets differed in type from the others in growing partly out of the ground. Analyses to determine the sugar from the parts above and below ground are presented in the following table.

TABLE III.—Showing percentage of sugar in different parts of beets.

Part of beet.	Weight.	Sugar in juice.
	Grams.	*Per cent.*
No. 22 { Upper half	664	9.89
No. 22 { Lower half	449	10.12
No. 23 { Upper half	345	11.81
No. 23 { Lower half	570	11.46

Though the percentage of sugar in the two parts of the beet does not vary much, the percentage for the whole beet is low.

Yield per acre.—At harvesting, the beets and tops were weighed separately. In the following table is shown the weight of the two grades, the tops, and the average weight of each beet-root.

TABLE IV.—*Showing yield of beets and weight of tops per acre.*

Variety.	No. of beets.	Weight of No. 1 beets.	Weight of No. 2 beets.	Total weight.	Average weight.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
California Beet Sugar Company	16,233	13,353	5,938	19,291	1.18
Vilmorin's Improved	15,770	12,211	3,384	15,595	.99
Lane's Imperial	14,713	11,856	4,501	16,367	1.11

The total yield of beets is much smaller than is usually reported. This is partly due to the season, but chiefly to the distance of the rows apart, it being the custom to plant them only 17 or 18 inches instead of 3 feet, as in this case.

The table shows that from a fourth to a third of all the roots graded as No. 2.

Both types of beets from the California Beet Sugar Company's seed were examined for sugar, two analyses of each being made, with the following results, which show that the No. 1 beets are the richest in sugar:

TABLE V.—*Showing per cent. of sugar in No. 1 and No. 2 beets.*

	No. 1 beets. Sugar in juice.	No. 2 beets. Sugar in juice.
	Per cent.	*Per cent.*
No. 1	14.83	14.12
No. 2	14.47	13.50
Average	14.54	13.81

Impurities in the juice.—Analyses were made to determine the quality of the juice for the manufacture of sugar. The following table gives the per cent. of sugar, of solids, and the specific gravity of the juice at the dates mentioned.

TABLE VI.—*Showing per cent of solids and sugar in the juice.*

Variety.	Date of analysis.	Solids in juice.	Sugar in juice.	Specific gravity of juice.
		Per cent.	*Per cent.*	
Lane's Imperial	Oct. 11	18.43	14.40	1.10
California Beet Sugar Company	Oct. 15	17.30	14.53	1.08
Do	Nov. 29	15.29	14.12	1.085
Do	Dec. 4	15.07	14.83	1.09
Do	do	15.22	14.47	1.0825
Do	Dec. 5	14.96	13.50	1.08

Quality of the juice in stored beets.—The harvested beets were stored in a barn cellar, the door of which was left open for circulation of air until danger of freezing. The temperature of the cellar ranged from 44° to 41° Fah. by a dry-bulb thermometer, and uniformly 1 degree lower by a wet-bulb thermometer, showing that the air was quite damp. Under these conditions the beets kept well. For the sugar content we may refer to Table VI, where the California beets show 14.53 per cent of sugar in the juice October 15, one week before they were taken from the ground for storage. The analyses for November 29 and the three succeeding dates show the percentage of sugar in the juice of the stored beets.

Conclusion.—Considering the season, the time of planting, and the conditions of culture, the beets certainly showed a very satisfactory sugar content. The weather being quite abnormal, it is but fair to withhold general statements until the work is repeated for at least one season. If this line is continued, an effort will be made to plant and cultivate after the manner of beet fields in sugar districts.

EXPERIMENTS IN IOWA.

Experiments were made at the Agricultural Experiment Station at Ames during 1888 and 1889, and the results of these experiments are published in Bulletin No. 8 of the Station, pages 321 to 326, inclusive.

These experiments were conducted under the direction of Prof. G. E. Patrick.

Four varieties of sugar-beets were grown in 1888 and two in 1889. Those grown in 1888 were from seed purchased from seedsmen in America under the names given below. The roots were harvested in due season and stored in a good root-cellar, but were not analyzed till January, 1889. For the methods of sampling and analysis reference is made to the bulletin above noted.

The varieties grown in 1888 were White Sugar Beet, Excelsior, Valmorin's Improved, and Lane's Improved. The mean weight of the first variety was 14.5 ounces; of the second, 17 ounces; of the third, 19 ounces, and of the fourth, 18 ounces. The results of the analyses of the juice of the different varieties are as follows:

Variety.	Solids, Brix at 17.5° C.	Sucrose.	Purity coefficient.
		Per cent.	
White Sugar Beet	19.50	14.12	73.7
Excelsior	16.14	12.73	78.8
Vilmorin's Improved	19.33	15.00	77.6
Lane's Improved	19.10	14.47	75.7

Professor Patrick makes the following remarks on the analyses:

These results taken by themselves lend some encouragement to the hope that the climate and soil of Iowa may prove well adapted to the development of sugar in the sugar-beet.

But a single year's trial in a single locality goes but little way in settling so great a question.

Different seasons as well as different soils will have their influence, and sometimes a marked one, on the quality of the crop. This truth, or if not this then another one which the investigator of these subjects must always bear in mind, namely, that seeds purchased from dealers are not always true to their catalogue names, is well illustrated by the results obtained in 1889 as compared with those of 1888, above recorded.

Two varieties were grown in 1889, viz, Lane's Improved and Vilmorin's Improved. The analyses were made on November 20–23. These beets were planted on the same ground as those of the previous year, but the ground had received a good dressing of barn-yard manure for the crop of 1889. The mean weights were as follows:

Lane's Improved, 42 ounces; Vilmorin's Improved, 25 ounces. The results of the analyses of the expressed juice were as follows:

Variety.	Solids, Brix., at 17.5° C.	Sucrose.	Purity, coefficient.
		Per cent.	
Lane's Improved	13.32	7.82	58.7
Vilmorin's Improved	17.80	12.64	71.0

The disastrous results of manuring beets with barn-yard manure are easily seen from the above table. The beets grew to an enormous size, and were consequently low in sugar. Professor Patrick supposed that the low content of sugar was due only in part to the manuring, and he accounts for it as follows:

First, by the character of the season in 1889—dry in the early part, cold and wet toward the end—together with the enrichment of the land with barn-yard manure.

Second, and with reference to the Lane's Improved mainly, by the quality of the seed, the same having come, without doubt, from stock badly crossed with an inferior kind of beet. This conclusion is reached as much from the appearance of the beets within and without, as from the results of analysis. The similar experience of many beside ourselves makes it evident that sugar-beet seed purchased from American seedsmen is very liable to prove untrue and disappointing.

For these reasons we do not regard the results of 1889 as having any real significance in the question of the adaptability of Iowa's soil and climate to the needs of the sugar-beet.

In addition to the work done with the beets grown at the Station a box of beets was received on the 19th of November, 1889, from Mercer County, Ill., sent by Edward H. Thayer, of Clinton, Iowa. The seed from which these beets were obtained was purchased in Germany, but the names of the varieties are not known. The mean weight of the beets was 23.5 ounces. They contained of sugar 15.25 per cent in the juice, and a purity coefficient of 75.73. It is evident from the above that the beets from Illinois were grown without the use of barn-yard manure and, although a little above size, were much better in every way for the production of sugar than the beets grown at the Station.

From the results obtained, it is not difficult to see that the soil and climate of Iowa are far better suited to the growth of the sugar-beet, for sugar-producing purposes, than for sorghum. In the experiments made with sorghum at the Iowa Station, and which are given on pages 327 to 336, inclusive, of the bulletin above mentioned, the mean percentage of sucrose in the juice of the Early Amber was found to be 14.11, while the purity coefficient was 76.76. The hopelessness, however, of expecting to make sorghum sugar profitably in Iowa is sufficiently indicated by the statement made on page 328 of the bulletin, which is as follows:

On the night of September 18 there came a killing frost, which within three days withered the cane leaves and soured the sap in the stalks, thus reducing our season for selective work to only ten days.

With a season of such brief duration, which is almost certain to be ended in September, it is not to be expected that sorghum sugar can be made successfully. With the beet it is quite different, since by proper siloing the season for manufacture can be continued indefinitely.

EXPERIMENTS IN NEBRASKA.

The following report*, by Professors Nicholson and Lloyd, on the growth of the sugar beet in Nebraska from seed received from the Department of Agriculture, shows the progress made in that State during

*For full report see Bulletin 13, Nebraska Station.

the past year in the cultivation of the sugar beet under the auspices of the agricultural experiment station of the State.

REPORT ON THE DISTRIBUTION OF SEED RECEIVED BY THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF NEBRASKA, FROM THE DEPARTMENT. OF AGRICULTURE, AT WASHINGTON, D. C.

Varieties received.—I. Sugar beets, Lane's Imperial and Vilmorin II. Sugar Cane, Early Amber, and Red Siberian

But two persons reported results from sugar cane seed, in both cases a large proportion of the seed failed to germinate.

Analysis of two specimens of EarlyAmber cane sent in, gave,respectively, 13 and 12.41 per cent of sucrose.

In regard to sugar beets, twelve samples of seed of Lane's Imperial were sent out.

Seven persons returned specimens of beets raised accompanied by very brief reports; all reported poor seed.

Average per cent of sucrose in these beets was 4.66; highest, 6.08; lowest, 2.50.

Thirty-three samples of seed of Vilmorin were sent out.

Twenty-three persons returned to us specimens of beets raised, accompanied by brief reports which gave but little information, except that a large proportion of the seed did not germinate.

In fifteen of the beets the per cent of sucrose ranged above. Average of the fifteen specimens, 14.67; average of the eight (under 10) specimens, 6.97; average of the entire lot, 11.99; highest per cent. in whole lot, 20.28; lowest per cent. in whole lot, 4.73.

Analysis of sugar beets, chemical laboratory, University of Nebraska.

No.	Date.	Consignor.	Variety.	Sucrose.	Glucose.	Brix.	Specific gravity.	Co-efficient of purity.
				Per cent.	*Per cent*			
1	Oct. 28	C. B. Kemple	Vilmorin	13.28	0.370	21.6	1.098	61
2	Oct. 29	H. C. Armstrong	...do	11.49	0.010	17	1.070	68
3	...do	S. M. Bates	Unknown	19.52	0.010	23.7	1.100	80
4	...do	W. M. Lowman	Vilmorin	9.91	0.052	19.3	1.082	51
5	...do	Ira Ford	do	10.14	0.009	20.4	1.085	50
6	Oct. 30	do	Red beet	10.13	0.017	19.3	1.080	52
7	Nov. 15	Mr. Rinker	Lane's Imperial	15.32	0.230	23.7	1.100	65
8	...do	F. Bates		13.51	0.100	23.7	1.100	58
9	...do	S. G. Johnson		9.69	0.160	23.7	1.100	40

H. H. NICHOLSON, *Director.*
RACHEL LLOYD, *Analyst.*

EXPERIMENTS AT GRAND ISLAND, NEBRASKA.

Great success also attended the growing of sugar beets in Nebraska, at Grand Island, in 1888. As will be seen by the following table, samples of these beets were analyzed by various chemists, and all found them excellent for sugar-making purposes.

Brix.	Sugar.	Co-efficient of purity.	Brix.	Sugar.	Co-efficient of purity.
	Per cent.			Per cent.	
*17.2	14.9	86.00	‡16.0	13.71	85.70
*18.9	16.1	85.00	‡17.1	14.2	83.00
*19.5	17.5	89.00	§16.3	13.10	80.40
*21.4	19.2	90.00	‖18.9	15.8	83.60
*19.7	16.7	84.00	‖18.2	15.20	83.50
*21.8	19.8	90.00	‖18.4	15.90	86.40
†18.8	16.4	87.10			

* Analyzed by Prof. William Huch, from Shoemingen, Germany.
† Beets harvested October 15, 1888 preserved in silo, analyzed January 2, 1889.
‡ Analyzed by Dr. Pauly, of Muhlberg, Germany.
§ Analyzed by Dr. Mueller, of Ottleben, Germany.
‖ Analyzed by Dr. Janke, Trendlebush, Germany.

Samples of these beets were also sent to the Department for analysis and entered as Nos. 6077 and 6078. The results of these analyses were as follows:

	6077.	6078.
	Per cent.	Per cent.
Juice extracted	56.16	54.70
Total solids in juice	18.40	18.80
Sucrose	15.38	15.75
Purity	83.59	83.77

As will be seen by the above analyses these beets were very rich in sugar, and if they could be grown in large quantities, which there is no reason to doubt, would indicate that in that locality the beet sugar industry could be successfully established.

EXPERIMENTS IN SOUTH DAKOTA.

Experiments were made at the Agricultural Experiment Station at Brookings, which are reported in Bull. No. 16, by Luther Foster, agriculturist, and James H. Shepard, chemist.

THE SUGAR-BEET.

The Station has completed its second season's test of the sugar-beet, and the result gives us still better evidence of its crop value to South Dakota both for stock feeding and sugar making. While the crop was not as great either in per cent of sugar or yield of roots per acre as may reasonably be expected in more favorable seasons, or by following more strictly the French and German methods of fertilizing and cultivating, it was still sufficiently large to insure it a profitable crop even under the opposing influences of the past season.

Preparation of soil.—In the whole matter of soil preparation, fertilizing, and cultivating, nothing has been attempted that is not within the reach of the ordinary farmer, and our results are no better than he may reasonably expect. In mechanical preparation the soil was almost perfect for such a crop, the ground having been deeply plowed and thoroughly pulverized. The results of long-continued experiments in beet-growing countries indicate an average depth in plowing of from 12 to 15 inches to insure the largest and best yield. Deep plowing prevents forking; it also provides a depth of mellow soil sufficient for the growth of the root entirely beneath the surface. Where beets grow partly above the soil the protruding portion becomes tinted and requires extra work in clarifying the sugar. Fall is the best time for plowing. It leaves a rough, uneven surface to weather, catch moisture, and settle. The final preparation should be made at planting time, avoiding any plowing or deep stirring that would cause a loss of the accumulated moisture of the winter. Thorough preparation before planting is of prime importance. Any neglect here will be a source of frequent annoyance and delay throughout the season of planting and cultivation. The clod-crusher and roller will greatly assist in this work.

Fertilizing.—The ground used for the experiment had received a heavy coat of well-rotted manure last year and was in excellent condition to nourish the season's crop. It is a fact well established by beet-growers that a too abundant supply of stable manure lessens the per cent of sugar. This results from a period of growth too rank and too much prolonged. To produce sugar the growth must be arrested in time for complete maturity. The dry, clear weather of this climate is favorable to this result. Stable manure should be applied and plowed under in the fall and not more than 15 tons per acre used.

Planting.—Experience has taught that the method of planting is of vastly greater importance than is ordinarily considered. It has been shown that not only the yield per acre but also the per cent of sugar depends largely on the manner of planting. Thin planting—rows wide apart and plants well separated from each other in the row—gives beets of the largest size but containing a small per cent of sugar, while the largest yield per acre both in per cent of sugar and quantity of beets is obtained from the thickest planting—rows narrow and beets close together in the row. In Dakota the high price of hand labor and cheapness of land would place the limit of thick planting to that width of row that can be easily cultivated with horse implements. That limit has been placed at 20 inches, but even 24 inches seems quite narrow for most of our single cultivators. Our planting in most cases has been made in rows thirty inches apart with the plants thinned to 8 inches apart in the row. One-half more plants can be grown with rows 20 inches apart, and with almost a half greater yield in pounds and a decidedly larger per cent of sugar. Our thickest planting was made in rows 14 inches apart with plants thinned to 6 inches apart in the row. This planting produced beets smallest in size but uniformly richest in per cent of sugar. It is generally admitted that the saccharine richness is inversely proportioned to the volume of the beet and that close planting gives beets of richer, better quality, of larger yield in weight and per cent of sugar, and at the same time exhausts the soil less.

The past season's planting was done the 10th day of May by hand. The furrows were made with an ordinary hand marker to whose runners had been attached small triangular pieces of wood to deepen and widen the marks. The furrows were 1½ inches deep; in these the seeds were drilled with a garden seeder and covered with the hoe, the covering being well-firmed to make it hold the moisture. The porous shell encasing the seed makes an extra amount of moisture necessary to reach the real seed within and cause it to grow. In this dry climate care should be taken to put the seeds down fully an inch and a half in order to secure the moisture needed to start them. Garden seed drills when used for planting should be in the hands of skillful operators to insure satisfactory results. Hand-planting has resulted best in our work.

Germination may be hastened by soaking the seeks in hot water for twenty-four hours just before planting. They can easily be made dry enough to plant with a machine by rolling them in plaster or dry soil.

Varieties planted.—The following is a list of the varieties planted with the names of the firms from which the seeds were purchased and the price paid for them per pound. When planted with a drill from 6 to 10 pounds per acre will be required, the amount depending upon the distance the rows are placed apart. Imperial, Silisian and red-top were furnished by D. Landreth & Sons, Philadelphia, at 40 cents per pound. Vilmorins imperial, Lane's improved and white sugar came from J. C. Vaughan, Chicago, the first at 60 cents and the others at 40 cents per pound. Salzer's imperial and sweet white, John A. Salzer, of La Crosse, supplied at 20 cents per pound.

In some instances the varieties are the same, no doubt, with different names.

Cultivation.—Early cultivation will kill the weeds at starting and form a layer of mellow earth which constitutes an obstacle to dryness.

The loosened layer acts as a mulch and tends to keep the soil below cooler while it prevents the water from reaching the surface to be evaporated.

The crop of the past season was twice hoed and four times cultivated. The implement used for the latter was an adjustable spring-tooth cultivator. This work began soon after the plants were up and continued until the middle of July.

Thinning.—This work can best be done just after a rain. The plants should be thinned to the proper distance in the row before the roots begin to develop. Where the planting is done with a drill, a sharp hoe may be used for thinning. The cutting must be deep enough to prevent any after growth of the roots cut off. In case the extra plants are pulled out, care should be taken not to loosen those that remain standing and thus check their growth. If the weather is favorable at the time of thinning the blank places may be filled in by transplanting, but the roots of the latter are usually found in several divisions instead of a single tap root.

Harvesting.—The crop should be pulled and stored in the root cellar or put in piles convenient for covering in the field before there is any danger of injury from freezing. In this respect they require more attention than other root crops. A temperature low enough to freeze the surface of the ground will destroy their keeping qualities. Beets injured in this manner should be fed out at once that they may not be an entire loss. Though the injury may seem at first very slight experience has shown us that they soon become spongy, then turn black, and finally rot. The usual plan of twisting off the tops as the beets are pulled has proven in our experience the safest and most economic method. While turnips, rutabagas, and carrots are not materially injured for keeping by having the root cut or broken, a beet so injured is apt to decay when stored.

Storing.—Sugar-beets and mangles require the same treatment in storage.

They should be placed in cool, moist cellars, making the piles not to exceed 4 feet in depth. In our dry Dakota cellars it is best to cover with damp earth to keep them from wilting. This will also help to protect from freezing. The dirt must be put directly on the beets, no straw or litter of any kind intervening. In this way we have kept them in the best condition into May.

VALUE FOR STOCK-FEEDING.

For feeding, the sugar-beet and mangle are the most reliable of all the root crops. Taken as a whole they have fewer enemies and are less liable to failure than almost any other crop grown in the State.

They are less liable to disease than either rutabagas or turnips, and less easily affected by drought. They also surpass them for feed in per cent of digestible nutrients. When the feeding value of 100 pounds of sugar-beets is 19 cents, that of 100 pounds of rutabagas is 15 and of turnips only 11 cents.

When properly stored they keep in good condition for feeding longer than any other root crop, under favorable circumstances keeping clear through the feeding season until the grass is ready to pasture in the spring. Both the feeding and keeping qualities depend upon complete maturity. Bulk of crop is not the only thing to be sought, neither are roots of unusually large size desirable. For the most satisfactory results in feeding, seek rather the weight in many roots of medium size perfectly ripened. Roots can not be relied on to supersede either hay or grain, but by being fed with them they greatly increase the value of both. Their succulence makes them an excellent stomach regulator, preventing the constipation that frequently comes form the continued use of dry foods. It is this quality, too, that makes them of special value to the dairyman for keeping up the flow of milk. They replace to a large degree the green succulent food of summer. All the stock on the farm relish sugar beets in winter. Sheep do excellently on them, and the greater part of their winter's supply of food may come from this source. A quantity should always be kept for ewes that wean their lambs before the grass starts. It should be noted, however, that for some time before the lambs come the ewe's ration of roots should be small since it is generally conceded that a full supply at this time has a tendency to produce abortion.

Hogs kept through the winter for breeding purposes should have a daily allowance of cut or pulped beets in connection with their dry food. They can thus be more economically kept, and they come through the winter healthier and in every way better prepared to farrow and raise their pigs. In all cases the roots fed should be cut into pieces small enough to prevent choking. A spade may be used for this purpose, but a root cutter is more convenient and does the work better and much more rapidly.

The beets were analyzed the last week in October. All the samples were in good condition. Samples 10, 11, and 12 were of the same variety, and were planted in different widths of rows and at different distances apart in the row. No. 11 was planted in rows 30 inches apart and thinned to 8 inches. No. 11 was thinly planted and No. 12 was planted very thickly. From an inspection of the table which follows it will be seen that the sugar yield depends largely on the manner of planting, other things being equal. It will also be interesting to compare the yield of sugar with the size of the beets:

[Four beets taken in each sample.]

	Weights.							
	No. 1.		No. 2.		No. 3.		No. 4.	
	Lbs.	*oz.*	*Lbs.*	*oz.*	*Lbs.*	*oz.*	*Lbs.*	*oz.*
Sample 8	0	12	1	$\frac{3}{4}$	1	$10\frac{3}{4}$	2	$2\frac{1}{2}$
9	0	$10\frac{3}{4}$	2	$4\frac{1}{4}$	2	$10\frac{1}{2}$	2	$14\frac{3}{4}$
10	0	$11\frac{1}{2}$	1	$5\frac{1}{2}$	2	12	3	$13\frac{3}{4}$
11	2	13	4	13	7	$15\frac{3}{4}$	15	$8\frac{1}{2}$
12	1	$1\frac{3}{4}$	1	$8\frac{1}{4}$	1	$14\frac{3}{4}$	2	$7\frac{3}{4}$
13	1	$\frac{3}{4}$	1	$15\frac{1}{2}$	3	$4\frac{1}{4}$	5	$4\frac{1}{2}$
14	0	$9\frac{1}{2}$	1	6	2	2	3	$14\frac{1}{2}$
15	1	$2\frac{1}{4}$	1	13	2	7	4	$7\frac{3}{4}$
16	0	$15\frac{1}{4}$	2	$3\frac{1}{4}$	2	$9\frac{1}{2}$	5	$12\frac{1}{4}$
17	0	$13\frac{3}{4}$	0	15	1	$13\frac{3}{4}$	2	14

In selecting samples for analysis, twelve beets of each variety were sent to the laboratory. These ranged from the smallest to the largest average beet which the variety afforded. At the laboratory four piles were made and from each pile an average beet was taken, thus securing a fair representation for each sample.

In obtaining the degree Brix, the pulp was placed in a canvas bag and the juice was forced out by hand. No press was available.

Station No. of sample.	Name.	Stand.	Yield per acre.	Sucrose.	Density of juice (Brix).	Marc.	Condition of pulp.
		Per ct.	*Lbs.*	*Per ct.*		*Per ct.*	
8	Silesian	75	23,600	10.0	14.2	3.76	Dry.
9	White	94	27,900	8.2	12.4	3.00	Somewhat dry.
10	Lane's Improved (ordinary planting).	88	31,200	10.2	15.3	3.56	Do.
11	Lane's Improved (thinly planted)	50	14,840	5.4	10.4	3.12	Moderately dry.
12	Lane's Improved (thickly planted).	50	16,680	9.9	15.2	3.63	Dry.
13	Red Top	75	23,850	10.2	15.1	3.85	Do.
14	Imperial	67	15,320	9.9	14.0	3.94	Do.
15	Vilmorin's Imperial	75	25,400	12.3	17.4	4.10	Do.
16	Salzer's Imperial	88	29,070	11.0	14.6	3.27	Moderately dry.
17	Sweet White	63	32,500	11.2	15.6	3.91	Dry.

Again hope is expressed that farmers will raise small quantities of the sugar-beet. All samples delivered at the Station laboratory will be analyzed free of charge.

Samples which had been harvested for three months were sent to the Department from Sturgis, S. Dak., in January, 1889, and entered under No. 6162, a rose-colored beet, and No. 6163, a white beet. These samples were sent by W. C. Buderus, of Sturgis, S. Dak. On examination of these beets the following numbers were obtained:

	6162.	6163.
	Per cent.	*Per cent.*
Juice extracted	36.05	42.77
Total solids in juice	20.40	21.48
Sucrose	13.32	15.03
Purity	65.29	69.97

The low purity of the beets represented above was doubtless due to the fact that they had been harvested for a long time and no precautions taken to preserve them from deterioration. The analyses show that such beets could also be profitably used for sugar-making if worked up in a fresh state or preserved in proper kinds of silos.

EXPERIMENTS IN KANSAS.

Tht Medicine Lodge Sugar Company last year (1889) made a series of experiments in the growth of sugar beets and the manufacture of sugar, the details of which follow:

Number of acres planted in beets	4.7
Tons of topped and cleaned beets produced	60.23
Pounds of sugar made	10,158
Gallons of molasses obtained	380

Of the total sugar made, 2,800 pounds were second sugars.

The beets did not receive altogether the attention which they should have had, and many of them grew quite a distance above ground. The beets were worked without any special appliances, but solely with the sorghum machinery which was at the factory. For this cause it is reasonable to suppose that the best manufacturing results were not obtained. Nevertheless, the results are gratifying, and show that with such a season as last, sugar beets can be grown in Kansas with a fair percentage of sucrose. In many cases the beets grown last year were of extraordinary size, in one instance weighing 12 pounds. By more careful preparation of the soil, and planting the beets closer together, and proper cultivation, it is reasonable to believe that a higher mean content of sugar might be obtained. The details of the analyses of the beets, by Mr. T. F. Sanborn, of this division, and the manufacture thereof are found in the following table:

Medicine Lodge, Kansas, season of 1889.—*Sugar beets.*

	Date.	Serial No.	Degree Brix.	Sucrose in the juice.	Purity.
				Per cent.	
Exhausted chips	Nov. 14	264	1.60	.62	38.75
Do	Nov. 15	269	2.24	.82	32.14
Mean			1.92	.72	35.44
Fresh chips	Nov. 14	265	13.74	9.00	65.50
Do	Nov. 15	270	12.09	9.67	71.71
Mean			12.92	9.32	68.60
Diffusion juice	Nov. 14	266	10.83	7.88	72.76
Do	Nov. 15	271	10.99	7.37	67.15
Mean			10.91	7.62	69.95
Clarified juice	Nov. 14	267	11.64	7.77	66.58
Do	Nov. 15	273	10.65	6.35	59.62
Mean			11.14	7.06	63.10
Semi-sirup	Nov. 14	268	29.32	18.80	64.12
Do	Nov. 15	274	25.26	18.10	71.61
Mean			27.29	18.45	67.87
Masse cuite	Nov. 16	22	77.71	34.04	43.82
Do	Nov. 24	24	85.68	49.51	57.78
Mean			81.69	41.77	50.80
Marc	Nov. 14			4.69	
Do	Nov. 15			5.01	
Mean				4.85	

		Sucrose.
Nov. 15. Scum from clarifiers	per cent..	5.00
Nov. 15. Scum from clarifiers, less lime	per cent..	3.00

POLARIZATION OF SUGARS.*

Date.	Serial No.	Sucrose.
		Per cent.
November 19	16	90.9
November 24	17	99.7
Mean		95.3

* Sugar not washed. No. 16, reboiled.

Miscellaneous samples of beets from field.

Date.	Serial No.	Degree Brix.	Sucrose in the juice.	Purity.
			Per cent.	
Aug. 23	7	19.62	14.58	74.31
Sept. 2	62	11.01	7.25	65.88
3	64	12.69	9.25	78.81
4	70	10.20	6.95	68.23
13	120	15.58	11.75	75.42
21	190	18.66	11.75	62.96
Nov. 8	306	13.75	9.35	68.00
11	317	15.59	11.00	70.55
12	318	13.55	9.35	69.00
12	319	16.28	13.10	80.46
12	320	16.80	13.95	81.84
12	321	14.26	10.40	72.93
12	322	16.17	12.65	78.23
Maximum		19.62	14.58	81.84
Minimum		10.20	6.95	62.96
Mean		14.93	10.85	72.64

Mr. Fred Hinze cultivated an experimental plot of sugar beets at Douglass, Kans., during the season of 1888. Considering the dryness of the climate and the high temperature reached during the summer, the results appear to be favorable. I am inclined to think, however, that the successful cultivation of the sugar beet for manufacturing purposes can not be looked for in such a climate as obtains at Douglass in competition with more favorable localities.

The analyses of the sugar beets at this station were made from time to time by my assistants at Douglass who had charge of the chemical work at the sorghum factory at that place. Following are the results of the work:

Date.	Degree Brix.	Sucrose in the juice.	Coefficient of purity.
		Per cent.	
Sept. 3	13.58	9.27	67.64
3	11.67	7.96	68.30
3	12 45	8.16	65.46
10	16.74	12.38	73.96
20	14.70	9.47	64.42
29	14.43	10.47	72.69
Oct. 11	15.95	11.98	75.11
Highest	16.74	12.38	75.11
Lowest	11.67	7.96	64.42
Average	14.22	9.36	69.65

EXPERIMENTS IN CALIFORNIA.*

The Alvarado, Cal., beet-sugar factory is situated on the east side of the bay, 24 miles from San Francisco.

The climate of Alvarado is a peculiar one, and, as experience has shown, very suitable to the development of a first-class sugar beet.

The winters are mild. Planting begins in February and can be continued up to the middle of May. The early planting matures in the

* Bull. No. 5, pp. 75 *et seq.*

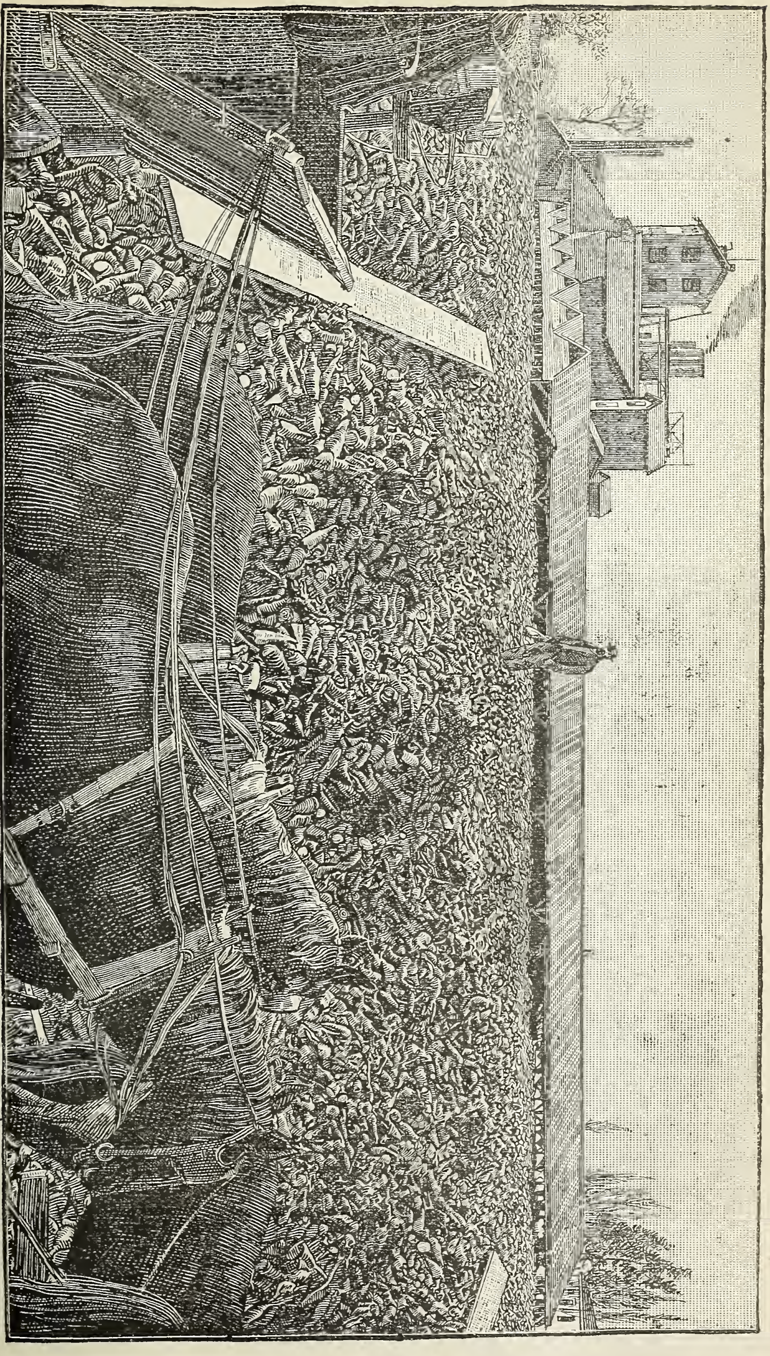


Fig. 43.—Sugar-Beets (nearly 20,000 tons), Alvarado, Cal.*

* From Sugar Industry of the United States, p. 77. Bulletin No. 5, Chemical Division, U. S. Department of Agriculture.

summer and the factory can be started by the middle of August. From this time until December there is a consecutive maturity of beets. The summers and falls are dry, and there is little danger of the beets taking a second growth by reason of early rains.

When harvested the beets do not require to be siloed, but are kept in heaps either with no covering at all or at most a little straw.

In the middle of December, 1884, the company had nearly 20,000 tons of beets on hand.

In Fig. 43 is seen this immense pile of beets, covering over 2 acres of surface and of 8 feet mean depth.

The land on which these beets are grown is level, the soil sandy and fertile, stretching from the bay eastward to the hills, a breadth of from 5 to 10 miles.

The following tables, prepared at my request by Mr. E. Dyer, superintendent of factory, exhibit the data collected from twelve different fields, representing a fair average of all the land in cultivation for beets in 1884.

The analyses represent a fair sample of beets taken from all the wagons during each day the beets were brought to the factory. The kind of seed used is also indicated in the tables.

Formerly all the seed planted was imported, but the company is now raising its own seed, and with the most encouraging results.

The expression "first and second year" indicates that the seed was native and one or two years from the imported seed.

In all the analyses made at Alvarado the sucrose is calculated on the weight of the beet and not of the juice.

FIELD OF JOHN LOWRIE.

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Coefficient of purity.	Remarks.
1884.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
Sept. 10	Native red, first year	15. 9	13. 4	2. 5	84. 2	Planted 315 acres; not all harvested yet; will average between 15 to 20 tons per acre.
15	Native white, second year	16. 9	13. 9	3.	82. 2	
20	Native red, first year	17. 3	14. 9	2. 4	86. 1	
25	......do	17. 9	15. 6	2. 3	85. 7	
30	......do	17. 2	15. 1	2. 1	87. 7	
Oct. 1	......do	18. 5	15. 7	2. 1	84. 8	
5	......do	17. 7	14. 7	3.	83.	
10	......do	17. 8	15. 5	2. 3	87. 6	
15	......do	17.	14. 4	2. 6	84. 7	
20	......do	16. 6	14.	2. 6	84.	
24	......do	13. 7	12. 6	3. 1	80.	
28	......do	17. 4	14. 3	3. 1	82. 1	
Nov. 9	......do	16. 5	13. 5	3.	81. 2	
13	......do	14. 8	11. 5	3. 3	77. 1	
16	......do	14. 5	12. 5	2.	86. 2	
18	......do	13.	10. 4	2. 6	80.	
22	Native white, second year	17.	14. 9	2. 4	87. 6	
24	Native red, first year	16. 2	13. 7	2. 5	84. 5	
Dec. 5	......do	15. 4	13. 2	2. 2	85. 7	
10	......do	15. 6	13. 2	2. 4	84. 4	

FIELD OF B. AZEVADA

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Co-efficient of purity.	Remarks.
1884.		P. ct.	P. ct.	P. ct.	P. ct.	
Nov. 5	Native white, second year	17.	14.	3.	82.9	Planted 10 acres; had 153.8 tons; yield per acre, 15.3 tons.
6	Native red, first year	16.2	13.2	2.4	85.1	
9	......do	16.8	14.3	2.3	86.3	
13	Native white, second year	17.4	15.4	2.	88.5	

FIELD OF JAMES NARCISSO.

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Co-efficient of purity.	Remarks.
Oct. 23	Native white, second year	16.1	13.1	3.	81.3	Planted 10 acres; had 237 tons; yield per acre, 23.7 tons.
Nov. 5	......do	16.5	13.6	2.9	82.4	
7	......do	15.2	13.	2.2	85.1	
13	......do	15.2	12.3	2.9	80.9	
20	......do	16.9	13.5	3.4	79.8	
23	......do	17.1	14.3	3.8	83.6	
24	......do	15.6	12.8	2.	82.	

FIELD OF J. G. VANDEPEER.

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Co-efficient of purity.	Remarks.
Oct. 21	Native white, second year	16.8	13.9	3.1	82.7	Planted 20 acres; had 360 tons; yield per acre, 18 tons.
24	......do	17.9	15.	2.9	83.2	
Nov. 1	......do	15.6	13.5	2.1	86.5	
3	......do	17.8	15.1	2.7	84.4	
4	......do	15.2	12.5	2.7	82.2	
6	Native red, first year	14.3	12.	2.3	83.9	
7	......do	14.2	12.	2.2	84.	
13	Native white, second year	17.2	14.3	2.9	83.1	
15	Native red, first year	14.2	12.	2.2	84.5	
17	Native white, second year	18.	16.1	2.4	87.5	
24	......do	17.	14.	3.1	82.3	
26	......do	16.3	14.	2.3	85.9	

FIELD OF FRANK MUNYAR.

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Co-efficient of purity.	Remarks.
Nov. 1	Native white, second year	16.2	13.9	2.3	85.	Planted 12 acres; had 246 tons; yield per acre, 20.5 tons.
6	......do	15.6	13.	2.6	83.3	
9	Native red, first year	16.8	14.	2.8	83.3	
11	......do	16.9	14.2	2.7	84.	
19	......do	15.2	12.6	2.6	80.7	

FIELD OF M. BAIN.

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Co-efficient of purity.	Remarks.
Oct. 24	Native red, first year	17.3	14.5	2.8	83.	Planted 18 acres; had 414 tons; yield per acre, 23 tons.
24	Native white, second year	18.4	15.8	2.6	85.9	
31	Native red, first year	15.2	12.	3.2	78.9	
31	......do	16.2	14.	2.2	86.4	
Nov. 2	......do	16.8	14.7	2.1	86.3	
5	......do	16.9	14.7	2.2	86.	
6	Native white, second year	16.9	14.2	2.7	83.7	
7	Native red, first year	15.	12.4	2.6	82.	
10	......do	17.2	14.5	2.7	84.3	
13	......do	17.2	15.	2.2	87.2	
18	......do	16.7	14.5	2.2	86.8	

FIELD OF A. GEORGE.

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Co-efficient of purity.	Remarks.
Oct. 21	Native white, second year	15.2	12.	3.2	79.	Planted 10 acres; had 153.8 tons; yield per acre, 15.3 tons.
29	Native red, first year	14.6	12.1	2.5	82.8	
1	......do	14.5	11.5	3.	79.3	
9	......do	14.6	12.	2.9	82.1	
16	Native white, second year	16.1	14.	2.1	86.9	
18	......do	16.7	13.1	3.6	78.4	

FIELD OF A. P. MACHADE.

Date.	Kind of seed used.	Total solids.	Sucrose.	Other solids.	Coefficient of purity.	Remarks.
1884.		*P. ct.*	*P. ct.*	*P. ct.*		
Oct. 24	Native white, second year	16.3	13.7	2.6	84.6	Planted 8 acres; had 152 tons; yield per acre, 19 tons.
28	......do	17.4	14.7	2.7	84.6	
Nov. 1	......do	17.4	15.3	1.9	89.6	
5	......do	16.2	14.	2.2	86.4	
10	......do	14.	11.6	2.4	82.5	
13	......do	14.6	12.5	2.1	85.6	

FIELD OF FRANK GEORGE.

Oct. 21	Imported white Imperial	18.3	15.5	2.8	84.7	Planted 10 acres; had 175 tons; yield per acre, 17.5 tons.
23	......do	16.8	13.	3.8	77.3	
Nov. 2	......do	16.2	12.9	3.3	79.6	
5	.... do	15.9	13.	2.9	81.6	
10	.... do	15.5	13.	2.5	83.8	

FIELD OF A. GASPER.

Oct. 21	Imported white Imperial	16.6	13.	3.6	78.3	Planted 7 acres; had 105 tons; yield per acre, 15 tons.
28	......do	16.2	13.8	2.4	85.	
Nov. 10	......do	15.7	13.	2.7	82.8	
14	......do	16.4	14.5	1.9	88.4	

FIELD OF JAMES FIRERA.

Oct. 24	Imported white from Fred. Knauer Germany.	15.3	12.5	3	80.1	Planted 5 acres; had 130 tons; yield per acre, 26 tons.
24	......do	15.2	11.5	2.7	75.5	
Nov. 4	......do	16.4	12.8	3	78	
11	......do	15.6	12.3	2.1	80.1	
13	......do	16.5	13.3	3.2	80.6	
19	......do	14.2	10.2	4	91.8	
20	......do	13.7	9.1	4.8	66.4	

FIELD OF FRANK P. ROSE.

Oct. 24	Native, red, first year	19.2	17	2.2	88.5	Planted 20 acres; had 474 tons; yield per acre, 23.7 tons.
24	Imported, white	16	13.6	2.4	85	
25	......do	17.3	13.2	3.5	78	
30	Native, red, first year	16.5	13.8	2.7	83.6	
Nov. 15	......do	17.6	15.3	2.3	86.9	
16	......do	17.3	15	2.3	86.6	
19	......do	16.5	13.8	2.7	83.6	
24	......do	16.3	13	3.3	79.8	

TABLES OF WORK AT FACTORY FOR EACH WEEK FROM SEPTEMBER 16 TO NOVEMBER 11.

Mr. E. F. Dyer also kindly furnished me with the following data illustrating the workings of the factory in detail for nine consecutive weeks.

These tables contain a large amount of most practical information as well as valuable scientific data.

EXPLANATION OF TABLES.

The analyses were made daily, and these are given as well as the mean for the week. The column headed "Diffusions" gives the number of diffusion cells filled each day. The degree Brix represents the per cent. total solids in the juice. The polarization gives the percentage of sucrose in the juice. This subtracted from the total solids gives the *difference* or solids not sucrose.

The percentage of sucrose divided by the percentage of total solids gives the "quotient" or co-efficient of purity.

The columns under "Filtration" show the density and alkalinity of the juice and semi-sirup as they come from the filter presses.

The loss of sugar in the pulps and waste waters is also given.

The percentage of lime carbonate in the animal charcoal when it is taken out for washing and reburning is also given. Last of all are the analyses of the melada as it comes from the strike pan on its way to the centrifugal. The summary gives the tons of beets worked per week and the yield of pure granulated sugar in percentages of the beets worked.

Record of working of Standard Sugar Refinery.

WEEK ENDING SEPTEMBER 16, 1884.

Date.	Diffusions.	Cossettes per 100 of juice.				Diffusion juice.			Saturation.		Filtration.						Loss per 100.			Char.		Melada.	
											First.		Second.							Ca CO_3.			
													Unfiltered.		Filtered.								
		Deg. Brix.	Sucrose.	Diff.	Quot.	Deg. Brix.	Sucrose.	Quot.	I. Alkalinity.	II. Alkalinity.	Deg. Brix.	Alk.	Deg. Brix.	Alk.	Deg. Brix.	Alk.	Pulp.	Waste water.	Slime.	First.	Second.	Sucrose.	
			Per ct.						Per ct.	Per ct.		Per ct.		Per ct.		Per ct.	Per ct	Per ct.	Per ct.	Per ct.	Per ct.		
10	71	15.9	13.4	2.5	84.2	12.8	10.4	81.1	0.168	0.123	9.7	0.084	43.7	0.226	41.8	0.151	0.4	1.4	......	14.6	......	......	......
11	69	16.6	13.3	3.3	80.1	12.9	10.3	79.8	0.210	0.182	15.9	0.092	48.5	0.159	47.6	0.106	0.2	1.2	......	......	11.55	83	......
12	67	17	14.6	2.4	84.3	12.8	10.2	80.7	0.182	0.082	13.4	0.070	47.5	0.200	45.0	0.095	0.15	0.1	......	15.5	......	......	......
13	67	16.8	13.6	3.2	82.6	13.2	10.5	82.6	0.173	0.143	13.5	0.080	49.5	0.168	47.8	0.077	0.1	1.6	......	9.6	6.6	......	......
14	69	16.9	14.1	2.8	83.4	12.7	10.5	82.2	0.200	0.196	13.1	0.098	49	0.126	40.2	0.070	0.1	1.7	......	......	......	......	......
15	75	16.9	13.9	3	82.2	13.2	10.3	78.0	0.184	0.142	11.8	0.075	51	0.250	49.3	0.159	0.3	......	......	......	12.9	82	......
16	74	17.6	15.2	2.2	86.3	12.4	10	80.6	0.187	0.176	11.6	0.061	49.1	0.215	44.8	0.097	0.1	1.3	......	......	......	......	......
Average ...	......	16.7	14.0	2.7	83.2	12.8	10,3	80.7	0.186	0.152	12.7	0.080	48.3	0.492	45.2	0.107	0.19	1.2	......	14.8	11.35	82.5	......

Tons of beets worked, 565. Per cent. of first product obtained, 9.5.

WEEK ENDING SEPTEMBER 23, 1884.

Date.	Diffusions.	Cossettes Deg. Brix.	Cossettes Sucrose.	Cossettes Diff.	Cossettes Quot.	Diffusion juice Deg. Brix.	Diffusion juice Sucrose.	Diffusion juice Quot.	I. Alkalinity.	II. Alkalinity.	First Deg. Brix.	First Alk.	Second Unfiltered Deg. Brix.	Second Unfiltered Alk.	Second Filtered Deg. Brix.	Second Filtered Alk.	Pulp.	Waste water.	Slime.	Ca CO_3 First.	Ca CO_3 Second.	Melada Sucrose.	
17	70	17.4	14.9	2.5	85.6	11.9	9.7	81.5	0.201	0.187	10.9	0.084	48.9	0.187	46.2	0.071	0.15	0.55	......	14	12.2	......	......
18	75	17.1	14.1	2.7	84.2	12.8	10.5	82	0.224	0.196	11.8	0.067	50.9	0.226	47.9	0.148	0.15	0.75	......	......	......	......	......
19	69	16.7	14	2.7	83.2	12.7	9.7	76.3	0.204	0.177	13.1	0.096	47.9	0.220	46	0.129	0.2	1.6	2.8	14.9	9.4	......	......
20	72	17.3	14.9	2.4	86.1	12.3	9.9	80.4	0.239	0.198	......	0.082	......	0.250	43.7	0.100	0.2	1.5	7.03	......	......	......	......
21	71	17.6	15.5	2.1	81	13.4	11.2	83.8	0.223	0.190	15.2	0.971	......	0.198	43.7	0.118	0.3	1.7	......	......	......	83.5	......
22	71	17.2	14.9	2.3	86.6	13.7	11.4	85.1	0.259	0.218	15.7	0.091	47.3	0.165	45.1	0.150	0.3	1.5	......	15.2	11.7	......	......
23	72	17.7	15.3	2.4	86.4	13.3	11.1	83.4	0.220	0.179	14.4	0,124	50.7	0.124	48.3	0.193	1.2	1.5	12.2	......	......	......	......
Average ...	......	17.2	14.8	2.4	85.5	12.8	10.5	81.7	0.224	0.192	13.6	0.087	49.1	0.195	46.2	0.129	0.34	1.30	7.34	14.7	11.1	83.5	......

Tons of beets worked, 565. Per cent. of first product obtained, 9.64.

WEEK ENDING SEPTEMBER 30, 1884.

24	78	16.2	14.0	2.2	86.4	13.4	10.6	79.1	0.212	0.187	15.1	0.091	46.8	0.220	44.3	0.128	0.6	1.7	......	13.3	11.4	83.05	......
25	73	17.9	15.6	2.3	85.7	13.6	11.0	80.9	0.234	0.179	15.8	0.138	46.4	0.223	43.1	0.149	0.2	1.5	8.44	......	......	......	......
26	64	17.4	15.1	2.3	84.7	13.0	11.3	86.1	0.182	0.231	16.2	0.091	47.1	0.242	45.2	0.165	0.5	1.8	......	......	14.7	11.4	......
27	78	16.6	14.5	2.1	87.3	14.2	12.0	84.4	0.262	0.220	16.0	0.124	......	0.265	......	0.138	0.5	1.2	8.74	......	......	......	......
28	68	17.9	15.9	2.0	88.8	13.4	11.8	87.1	0.234	0.176	15.2	0.102	47.3	0.303	44.0	0.160	0.7	1.1	......	......	......	81.7	......
29	73	17.6	15.4	2.2	87.5	12.8	10.7	83.5	0.158	0.138	14.9	0.082	48.9	0.234	46.8	0.171	0.9	1.6	......	15.63	12.59	......	......
30	72	17.2	15.1	2.1	87.5	13.5	11.1	82.2	0.248	0.176	......	0.091	......	0.135	......	0.165	......	1.4	......	......	......	81.0	......
Average	......	17.2	15.0	2.1	86.8	13.4	11.2	83.3	0.218	0.186	15.5	0.102	47.3	0.231	44.6	0.155	0.5	1.4	8.59	14.54	11.79	82.06	......

Tons of beets worked, 566.72. Per cent. of first product obtained, 9.54

WEEK ENDING OCTOBER 7, 1884.

1	62	18.5	15.7	2.1	84.8	14.5	13.2	83.7	0.248	0.175	13.6	0.091	50.8	0.256	48.7	0.151	0.10	1.2	10.69	15.21	12.97	82.8	......
2	65	17.0	14.6	2.4	85.8	14.3	11.5	80.4	0.242	0.165	13.6	0.088	50.8	0.251	47.3	0.171	0.30	0.5	9.06	11.16	......	......	......
3	74	18.1	15.0	3.1	83.4	14.3	12.2	85.3	0.171	0.096	14.6	0.0828	48.9	0.181	47.5	0.171	0.15	0.10	......	......	12.2	83	......
4	68	17.7	15.2	2.5	85.8	13.9	11.9	83.6	0.194	0.160	14.6	0.102	50.0	0.187	45.0	0.170	0.6	0.8	9.63	......	......	......	......
5	72	17.7	14.7	3.0	83.0	14.1	11.6	82.2	0.234	0.160	15.3	0.082	47.2	0.151	44.9	0.123	0.3	0.7	......	......	......	......	......
6	64	17.9	15.2	2.7	84.8	14.7	12.2	85.6	0.198	0.165	17.0	0.096	44.5	0.160	44.5	0.151	0.3	0.35	......	12.23	14.42	83	......
7	61	16.6	14.4	2.2	86.8	14.1	11.1	78.7	0.234	0.123	15.1	0.089	45.3	0.124	40.8	0.082	0.2	1.10	9.52	......	......	......	......
Average	......	17.6	14.9	2.7	84.0	14.3	11.8	81.8	0.217	0.149	14.8	0.0786	48.2	0.187	45.5	0.144	0.27	0.67	9.72	13.68	13.09	82.9	......

Tons of beets worked, 521.92. Per cent. of first product obtained, 9.7.

WEEK ENDING OCTOBER 14, 1884.

8	70	17.0	14.4	2.6	84.7	14.3	12.0	83.2	0.220	0.209	15.2	0.199	44.9	0.157	44.8	0.110	0.10	0.3	......	......	1.03	......	......
9	66	17.9	15.3	2.4	86.7	13.4	11.5	85.8	0.195	0.187	15.8	0.110	44.9	0.219	41.0	0.124	0.15	0.1	9.06	12.0	......	83.1	......
10	57	17.8	15.5	2.3	87.6	13.8	11.4	85.2	0.251	0.165	17.0	0.138	44.0	0.201	44.3	0.188	0.15	0.3	......	12.3	8.6	83.3	......
11	26	18.4	16.6	1.8	90.1	13.5	10.7	79.2	......	......	......	0.096	......	......	......	......	......	0.1	......	......	......	......	......
12	71	......	......	......	......	13.3	11.4	85.7	0.193	0.165	14.2	0.110	46.7	0.193	39	0.140	0.17	0.1	......	......	......	......	......
13	62	17.8	15.2	2.4	86.5	13.5	10.7	79.2	0.201	0.146	15.1	......	45.5	0.182	41.1	0.124	0.30	0.2	......	14.8	......	......	......
14	72	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Average	......	17.8	15.4	2.4	86.5	13.5	11.3	83.7	0.172	0.174	15.4	0.135	45.2	0.190	42.0	0.127	0.17	0.185	9.06	13.0	4.81	83.2	......

Tons of beets worked, 476. Per cent. of first product obtained, 11.1

Record of working of Standard Sugar Refinery—Continued.

WEEK ENDING OCTOBER 21, 1884.

Date.	Dif-fu-sions.	Cossettes per 100 of juice.				Diffusion juice.			Saturation.		Filtration.						Loss per 100.			Char.		Melada.	
											First.		Second.							Ca CO₃.			
													Unfiltered.		Filtered.								
		Deg. Brix.	Su-crose.	Diff.	Quot.	Deg. Brix.	Su-crose.	Quot.	I. Al-kalin-ity.	II. Alka-linity.	Deg. Brix.	Alk.	Deg. Brix.	Alk.	Deg. Brix.	Alk.	Pulp.	Waste water.	Slime.	First.	Sec-ond	Su-crose.	
			Per ct.						*Per ct.*	*Per ct.*		*Per ct.*		*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		
15	74	17.0	14.4	2.6	84.7	13.7	11.0	80.5	0.229	0.170	15.2	0.140	46.7	......	39.3	0.138	0.30	0.3	7.12	13.12	......	......	......
16	64	16.4	13.8	2.6	84.1	13.7	11.0	80.3	0.182	0.150	15.8	0.124	47.8	0.27	43.5	0.173	0.25	0.1	......	......	......	......	......
17	63	16.9	14.1	2.8	83.1	13.8	9.1	76.5	0.176	0.096	15.0	0.096	47.1	0.242	41.8	0.157	0.10	1.2	7.57	......	......	82.3	......
18	71	......	......		......	......	......		......		......		......					......	......	......	......	......	......
19	80	17.3	14.7	2.6	84.9	13.0	9.5	73.0	0.182	0.178	14.6	0.126	44.5	0.303	45.3	0.178	0.15	0.5	......	......	......	......	......
20	75	16.6	14.0	2.6	84.0	12.6	9.5	78.1	0.212	0.176	14.1	0.138	47.2	0.317	46.1	0.202	0.60	0.9	......	16	12.6	81.6	......
21	77	16.4	13.3	3.1	81.0	12.9	10.5	81.5	0.176	0.138	14.7	0.121	47.5	0.317	46	0.173	0.35	1.1	8.2	......	......	......	......
Average	......	16.8	14.0	2.8	83.3	13.3	10.1	75.9	0.191	0.151	14 7	0.124	46.8	0.207	43.6	0.170	0.29	0.68	7.63	14.56	12.6	81.9	......

Tons of beets worked, 564.4. Per cent. of first product obtained, 9.9.

WEEK ENDING OCTOBER 28, 1884.

Date.	Dif-fu-sions.	Cossettes Deg. Brix.	Cossettes Su-crose.	Diff.	Quot.	Diffusion juice Deg. Brix.	Diffusion juice Su-crose.	Quot.	I. Al-kalin-ity.	II. Alka-linity.	First Deg. Brix.	First Alk.	Unfiltered Deg. Brix.	Unfiltered Alk.	Filtered Deg. Brix.	Filtered Alk.	Pulp.	Waste water.	Slime.	Ca CO₃ First.	Ca CO₃ Second	Melada Su-crose.	
22	74	16.0	12.9	3.1	80.6	12.2	9.0	73.7	0.176	0.138	14.7	0.121	47.5	0.317	41.8	0.173	0.50	0.6	......	14.5	13	......	......
23	69	14.8	11.7	3.1	79.0	12.2	8.8	72.1	0.168	0.138	14.9	0.090	47	0.276	44.	0.171	0.10	0.5	6.35	......	......	......	......
24	69	14.8	12.3	2.5	83.0	11.7	9.4	80.3	0.165	0.149	16	0.108	46.9	0.240	42.5	0.151	0.20	0.8	......	12.6	11.5	......	......
25	76	14.1	11.6	3.0	82.2	12.8	9.4	73.4	0.171	0.156	13.8	0.085	47.3	0.251	44.3	0.154	0.20	0.9	10.8	......	......	84	......
26	73	15.9	12.9	2.9	81.1	12.2	9.2	75.4	0.182	0.138	13.8	0.082	47.3	0.201	38.9	0.126	0.15	0.7	......	......	......	......	......
27	74	16.5	13.6	2.5	82.4	11.8	9.0	76.2	0.160	0.121	14	0.080	45.9	0.204	40.7	0.126	0.15	1.0	......	13.2	10.4	......	......
28	80	15.4	12.8	2.6	83.1	11.2	8.2	73.2	0.193	0.153	14	0.069	46.8	0.208	41	0.114	0.30	0.7	6.82	......	......	85.5	......
Average	......	15.4	12.5	2.9	81.1	12.0	9.0	75.0	0.173	0.146	14.3	0.091	47.0	0.242	42.2	0.145	0.23	0.74	7.99	13.4	11.6	83.7	......

Tons of beets worked, 576.8. Per cent. of first product obtained, 9.3.

WEEK ENDING NOVEMBER 4, 1884.

29	73	13.9	11.9	2.0	83.1	12.8	9.1	71.0	0.209	0.151	13.6	0.074	47.1	0.179	42.2	0.129	0.5	0.8	......	15.5	13.2	82	......
30	76	12.3	10.7	1.6	86.9	11.4	8.6	73.5	0.220	0.118	14.7	0.077	47.4	0.179	43.5	0.118	0.2	0.6	8.3	......	......	......	......
31	75	12.4	9.7	2.7	78.2	11.4	8.4	73.3	0.193	0.124	14.6	0.096	46.5	0.220	43.8	0.121	0.2	0.7	......	15.0	13.2	81	......
1	74	16.0	13.0	2.6	83.7	11.9	9.2	77.3	0.207	0.118	13.7	0.079	43.1	0.207	42.1	0.151	0.1	0.7	7.1	......	......	......	......
2	69	14.1	12.1	2.0	85.8	11.0	8.1	73.3	0.179	0.151	13.7	0.113	43.6	0.179	42.2	0.113	0.2	0.6	......	......	......	82.2	......
3	69	15.4	12.8	2.6	83.1	11.9	9.6	80.6	0.171	0.138	14.4	0.120	45.0	0.252	42.3	0.165	0.2	0.5	......	......	14.2	......	......
4	71	16.0	12.9	3.1	80.6	11.9	9.2	77.3	0.219	0.185	12.9	0.118	47.9	0.262	44.0	0.152	0.5	0.5	......	......	......	......	......
Average	......	14.3	11.9	2.4	83.2	11.8	8.2	74.5	0.199	0.132	14.1	0.096	45.8	0.211	42.9	0.136	0.27	6.63	7.7	15.25	13.5	81.7	......

Tons of beets worked, 567.84. Per cent, of first product obtained, 8.4.

WEEK ENDING NOVEMBER 11, 1884.

5	75	15.9	13.6	2.3	85.5	11.7	9.2	78.4	0.189	0.143	14.7	0.110	43.2	0.231	38.3	0.082	0.30	0.5	7.5	16.1	13.6	82.5	......
6	55	15.1	12.4	2.7	82.1	11.3	8.6	76.1	0.204	0.165	13.6	0.112	45.7	0.207	44.6	0.151	0.30	0.7	......	......	......	......	......
7	14	......	......	......	......	12.7	10.2	80.3	......	......	......	......	......	......	......	......	......	0.8	......	......	......	83	......
8	79	13.2	10.5	2.7	79.6	13 1	10.6	80.9	0.197	0.151	12.6	0.074	45.2	0.138	40.8	0.110	0.10	0.7	10.5	......	13.3	......	......
9	77	14.8	12.4	2.4	83.7	11.7	9.0	76.8	0.201	0.193	13.2	0.096	44.2	0.234	45.4	0.129	0.40	1.0	......	......	......	......	......
10	78	14.3	11.6	2.7	81.1	11.4	8.5	74.5	0.187	0.151	14.0	0.099	......	0.234	40.5	0.138	0.15	0.3	......	......	11.5	82.3	......
11	76	16.6	14.2	2.4	85.5	12.0	9.0	75.0	0.183	0.180	14.2	0.082	43.9	0.220	39.9	0.138	0.20	0.4	7.74	......	......	......	......
Average	......	14.9	12.4	2.5	82.9	11.9	9.3	76.0	0.196	9.163	13.7	0.095	44.6	0.210	41.5	0.124	0.24	0.62	8.85	16.1	12.8	82 9	......

Tons of beets worked, 503.4. Per cent. of first product obtained, 9.5.

ANALYSIS OF CALIFORNIA BEETS MADE BY THE BUREAU OF CHEMISTRY AT WASHINGTON.

In order to render the results of the analyses made by Mr. E. H. Dyer more emphatic, I selected ten samples of beets, some from wagons as they were unloading, and some from the large pile of beets on hand, and sent them to Washington for examination.

The results of the analyses of these beets are given in the following table:

Analyses of California beets.

Variety.	Number.	Number of beets.	Weight in grams.	Per cent. of juice extracted.	Specific gravity.	In juice. Per cent. of reducing sugar.	In juice. Per cent. of sucrose.	Total solids calculated.	Total solids weighed.	Per cent. ash.	Co-efficient calculated.	Co-efficient found.
Imperial Rose	1	8	4,237	51.80	1.071	.190	14.46	17.23	17.41	1.136	83.9	83.1
Imperial White	2	7	4,350	65.61	1.068	.084	13.59	16.53	16.23	.930	83.2	83.7
Imperial or White Silesian	3	7	4,565	59.08	1.070	.082	14.69	17.01	17.13	1.134	86.4	85.8
White Silesian	4	8	3,555	58.41	1.074	.057	15.85	17.92	18.29	.822	88.5	86.7
Imperial	5	8	2,902	64.13	1.063	.069	14.92	15.39	17.40	.844	96.9	85.7
Improved Imperial Red	6	6	3,490	65.07	1.069	.061	13.59	16.77	17.60	.956	81.0	77.2
White Imperial	7	6	3,285	62.34	1.075	.129	15.19	18.14	18.40	1.009	83.7	82.6
Imperial Rose	8	7	3,585	66.63	1.063	.075	13.65	15.39	15.62	1.233	88.7	87.3
White Imperial	9	6	3,253	62.68	1.062	.109	12.71	15.16	15.29	.928	83.8	83.1
White Imperial	10	8	3,530	58.06	1.067	.050	15.19	16.30	18.58	.950	93.2	82.1
Means	....	....	3,675	61.38	......	.91	14.38	16.58	17.20	.994	86.9	83.7

REMARKS.—No. 1, Imperial Rose; in sheds from October 15 to November 20. No. 2, Imperial White; native seed, two years; wagon. No. 3, Imperial or White Silesian; in sheds from October 15. No. 4, White Silesian; native seed, two years; wagon. No. 5, Imperial; native seed, one year. No. 6, Improved Imperial Red; native seed, one year; wagon. No. 7, White Imperial; native seed, two years; wagon. No. 8. Imperial Rose; native seed, one year; wagon. No. 9, White Imperial; native seed, two years; wagon. No. 10, White Imperial; wagon.

REMARKS ON PRECEDING TABLES.

The richness of the beets worked during the nine weeks is fully equal to the average European standard.

Thirteen per cent. of sucrose indicates a kind of beet that can be successfully manufactured.

The yield of pure granulated sugar, designated as "first product," is for the nine weeks nearly 9.5 per cent., or 190 pounds of sugar per ton of beets. This large yield is obtained by remelting the second sugars and working the solution with the fresh juices. This method gives a maximum of "first product," no second product at all, and scarcely any in sugar of "thirds," or molasses. Indeed the quantity of molasses made by the Alvarado factory is quite insignificant.

Placing the yield in beets per acre at 15 tons, the lowest average, it is found that the total yield of sugar per acre is $190 \times 15 = 2,850$ pounds. The actual yield, however, in all except a few poorly cultivated fields, has been nearly 4,000 pounds, or 2 tons per acre.

Later in the season, *i. e.*, during late winter and early spring, the content of sucrose in the beets will slowly decrease, and by May 1 it is expected that it will be so low that the further manufacture of sugar will not be profitable. But even by that time the company will have still several thousand tons of beets on hand, on which it now seems probable they will suffer financial loss.

This excess of beets came about in this way: In former seasons the difficulty has been to get the farmers interested in beet-raising to grow enough to secure a liberal supply. The company, therefore, had urged farmers to plant, and agreed to take all the beets offered at a stipulated price.

During the campaign of 1883–'84 the farmers clearly saw that beet-raising was far more profitable than the culture of wheat or any of the usual crops. They therefore gave much more land and labor to beet-culture for the campaign of 1884–'85 than they had ever done before. The result has already been stated.

In a letter dated January 31, 1885, Mr. Dyer says:

> Our total receipts of beets this campaign were 20,358 tons (2,000 lbs.). The total amount of refined sugar manufactured and sold this campaign to date is 1,819,266 pounds.

Under date of March 9, 1885, he writes:

> We have beets to last through April. They keep well, and still show a co-efficient of purity of over 75.

If the yield continues, as expected, through April, the total output of refined sugar will exceed 3,000,000 pounds.

The study of the preceding tables is a most encouraging one for the farmers. These soils are easily cultivated. In no case was any fertilizer employed, and yet the yield and quality of the roots are fully up to the standard of the forced and expensive cultivation of Germany.

Although the price of labor in California is so much greater than in Germany, I doubt very much whether the cost of the beets per ton is greater. The largest item of expense to the beet farmer in these valleys of the coast range is rent. As much as $20 per acre is paid annually for beet lands.

Lands of equal fertility and adaptation for beets farther from San Francisco could doubtless be obtained on better terms.

YIELD PER ACRE.

The large differences in yield per acre shown in the preceding tables are not so much due to variation in the fertility of the soil as to methods of cultivation.

The experience of six years has shown that the average yield of beets per acre has steadily increased, and this increase has been due to improved agriculture alone.

At first the farmers (the company does not grow beets) were largely ignorant of the correct method of beet culture, and as this ignorance disappears the results are seen in an increase of the crops.

The factory at Alameda has lately been reorganized and supplied with new machinery. It is now known as the Alameda Sugar Company, and its operations during the past season are given in a letter from the president of the company published in another place.

[From the Rural Californian, October, 1889.]

SUGAR-BEET CULTURE IN SOUTHERN CALIFORNIA.—THE NADEAU EXPERIMENT.—THE CHINO AND SANTA ANA BEETS.—CLIMATIC CONDITIONS.—VILMORIN ON THE SUGAR BEET.—ARE WE TO HAVE SUGAR FACTORIES?

"The culture of the sugar beet in southern California has been in fits and starts, rather than a steady undertaking like the growing of other crops. That the beet will do well in our soil and climate has long since been demonstrated, and its sugar-bearing qualities being above those of the European growth, has always made its extensive propagation desirable, and a very interesting subject from a commercial point of view. The principal objection to its extensive cultivation has been the want of a market to enable the grower to dispose of his product at a remunerative price. This can only be created by the investment of capital in buildings and machinery to convert the raw material into merchantable sugar. Owing to this difficulty our farmers have not taken the active nterest in the sugar beet that they undoubtedly would if they had the assurance of a good market. On the other hand, capital has also been shy in seeking investments in sugar factories, not knowing for a certainty that a sufficient quantity of beets would be grown in convenient proximity to the factory, or within easy access by rail, to warrant the construction of immense buildings and machinery for this purpose. The experiments that have been made are for the most part very satisfactory, and clearly show that by proper cultivation, and planting only the best varieties, our soil and climate will yield a beet giving a large per cent. of saccharine matter. When once demonstrated that a large area of our land is adapted to the sugar beet, and our farmers will take a live interest in its culture, capital will be found ready to invest in the necessary buildings and machinery for purposes of refining.

"In this connection it will be of interest to refer to the experience of the late Mr. Nadeau. In 1880 he planted about 700 acres to sugar beets, with the intention, if we recollect correctly, of erecting a factory of his own to convert them into sugar. Be this as it may, he did raise an immense quantity, which on analysis demonstrated that in sugar-producing qualities they were up to if not above the standard of beets grown in Germany and France. The following correspondence gives the results of two analyses, one by Professor Hilgard, of the State University, and the other by Mr. Kulburg, chemist of the Standard Sugar Company, Alvarado:

ALVARADO, CAL., *November* 1, 1886.

DEAR SIR: The 20th day of September we received about 50 tons of dried beets from Mr. R. Nadeau, of Los Angeles, to be manufactured into sugar. As we were running on our own beets at the time we could not stop to work the whole 50 tons, but manufactured about 8 tons into a fair quality of sugar, sufficient to thoroughly test the feasibility of making sugar from sun-dried beets.

Mr. Nadeau sent us at the time some green beets. By polarization they gave about the same result as the dried beets. We made two polarizations with the following results, both taken from two different fields:

Sacchrometer	19.0	Sacchrometer	20.0
Polariscope	11.9	Polariscope	12.8
Difference	7.1	Difference	7.2
Quotient	62.62	Quotient	64.0

These beets were worked and the polarizations were made by Mr. Wm. Kulburg, who has charge of the technical department of our sugar works, and who has had experience in working dried beets in Europe.

* * * We have procured from Mr. Nadeau samples of his fresh beets, as well as those dried by him, and take the liberty to forward the same to you to enable you to make a further test from reliable samples. The samples of beets are somewhat wilted and dried in consequence of having been so long in reaching this place, consequently will polarize more than if taken fresh from the ground. I give the result of Mr. Kulburg's polarization, carefully made by him, October 30, 1880:

Saccharine	16.5	Saccharine	18.5	Saccharine	17.0
Polariscope	11.5	Polariscope	13.6	Polariscope	13.2
Difference	5.2	Difference	4.9	Difference	5.8
Quotient	68.0	Quotient	73.50	Quotient	65.6

Hoping you will favor us with an early reply, we remain,

Respectfully yours,

STANDARD SUGAR MANUFACTURING COMPANY,
By E. H. DYER,
General Superintendent.

E. W. HILGARD,
Professor of Agriculture, State University, Berkeley.

UNIVERSITY OF CALIFORNIA, COLLEGE OF AGRICULTURE,
Berkeley, November 6, 1880.

DEAR SIR: Yours of the 1st inst., with packages of fresh and dried beets, duly received.

The dried beets are now in process of analysis. The fresh beets were polarized immediately after receipt. The results agree substantially with those obtained by Mr. Kulburg, viz.:

Saccharine	17.1	Saccharine	17.2
Polarization	12.8	Polarization	12.3
Purity co-efficient	74.9	Purity co-efficient	71.5

Except in a higher purity co-efficient as an average, but that can easily happen. Except as to the same point, your polarization of beets taken from two fields as given on page 2 of your letter, also agrees; that is, all show a sugar percentage above 12, averaging about 42.5 in the juice. Now, since the juice constitutes about 95 per cent. of the fresh beet, this would correspond to a little less than 12 per cent. of sugar in the green beet; and this, at the rate of four to one, accepted by you, would make up about 48 per cent. in the absolutely free beets, or 43.2 in those containing 10 per cent. of moisture. A determination of the sugar in a sample of dried beets furnished me by Mr. Nadeau, gives 42.1 per cent. of sugar, corroborating, as nearly as possible, the polarizations made and the assumptions of the proportion of four of fresh beets to one of dry. I am at a loss to understand the statement apparently made on page 1 of your letter that the polarization on page 2 agrees with the assumption of 20 per cent. of sugar in the dried beets at the rate of four to one. On its face it gives it fully double, or over 40 per cent. Please revise and explain your position on this point. I remark that the dried sample sent by you is much more moist and to the taste much less sweet than the samples furnished by Mr. Nadeau. I am, of course, unable to determine which samples represents the fifty tons most correctly.

Very respectfully,

E. W. HILGARD.

E. H. DYER, Esq.,

Superintendent Standard Sugar Manufacturing Company, Alvarado.

"The facts are substantially as follows: Mr. R. Nadeau had about 700 acres of sugar-beets grown. The samples of green beets grown here upon comparison with the standard sugar-beet of Germany, show that those grown in this county are fully up to the standard. The exhibit of beets made by this gentleman at the horticultural fair in October was exceedingly fine, and from the judgment of non-professionals they were considered first-class for sugar-making purposes.

"There were several other letters passed between Professor Hilgard and the Standard Sugar Company, the tenor of which, on the part of the former, seemed to intimate that the Nadeau beets had not been fairly dealt with by the latter. Unsatisfactory, in so far as pertained to the manufacture of sugar, as this initial experiment proved to be, it clearly showed that with the crude appliances used by the Standard Sugar Company, according to Mr. Dyer, only 12 per cent. of sugar was obtained from these beets. The late improvements in machinery make it not improbable to increase the per cent. of sugar from these same beets to 17 and 18 per cent., and possibly still more.

"Owing to other investments and business cares the building of a sugar-beet factory was abandoned, Mr. Nadeau sun-dried his beets and fed them to his stock. This has been the largest experimental effort that has ever been made in Southern California to grow sugar-beets, and proved that in our soil and climate it luxuriates as nowhere else. These beets were grown within a few miles south of Los Angeles, on a sandy loam soil.

"From that time to the present the cultivation of this crop has more or less occupied the attention of our farmers and business men, but no systematic effort has been made to prove the adaptability of large areas of our lands to the cultivation of the sugar-beet as an article of commerce.

"Recently, however, sugar-beet cultivation has again been agitated owing to the fact that it is reported that the corporation of which the Spreckles are the leading spirits is contemplating building a series of sugar-beet factories in various portions of the State, and asking farmers to experiment growing beets in their respective localities. As a prerequisite for the erection of a factory in any locality, Mr. Claus Spreckles writes to the State Board of Agriculture:

Before erecting a factory anywhere I must be guarantied that at least two thousand five hundred acres will be planted in beets each year for a definite number of years. I must also be assured of sufficient supplies of wood, water, and lime in the neighborhood and good transportation facilities.

"The Los Angeles Chamber of Commerce sought to stimulate the interest in sugar-beets, and distributed some fifty packages of seed among the farmers of this county, hoping, by excellent returns to induce a sugar factory to locate here. Somehow, the experiment did not "pan." The recipients of seed paid very little attention to properly seeding and cultivating, and the result on the whole was very unsatisfactory. The few samples submitted to the chamber for analysis in July did not quite reach the standard, though it is conceded that under proper cultivation much better results could have been obtained. The best beets submitted were grown in the Cahuenga Pass, giving a very encouraging percentage of saccharine matter. Farmers in this favored locality are confident that it will grow a fine quality of beet, and are going to keep on experimenting.

"The results obtained from plantings made in last February and March on the Chino ranch, San Bernardino County, are more encouraging. The following, giving the particulars of the analysis of beets grown on the Chino ranch is taken from the Chino Champion:

Mr. J. G. Oxnard, of the American Sugar Refinery in San Francisco, spent part of Tuesday on the Chino ranch. In company with Mr. D. McCarty, he inspected several patches of sugar-beets and made tests of a few samples with satisfactory results. Among the tests made was one from J. E. Bettler's third planting of French seed on April 23, which gave 15 per cent. cane sugar and 83½ purity. By the way, the results thus far obtained are favorable to the French rather than to the German. Mr. Oxnard inspected beets grown by Messrs. Lawrence, Karcher, Bettler, Mrs. Rice, and others. In the case of the Lawrence beets the samples were taken from the outside and inside rows, which was not quite just, as it is well known that outside rows run low in sugar, and yet the result was 14 per cent. cane sugar,

Mr. Oxnard did not hesitate to say that he had never seen better beets, that he was well pleased with general shape and cork-screw form of growth, and also of the quality.

This much can now be stated with absolute certainty: The Chino damp and dry lands will grow sugar-beets, in fact have grown them, to the satisfaction of expert manufacturers; that in several cases the land upon which the experiments have been made has been cultivated but one year and none of it more than two, and experience proves that the first year land is cultivated the best results are rarely obtained. In some instances where the per cent. of sugar and purity are above the standard the seed was planted and the beets left to grow their own way except that the weeds were kept down, and in but few cases were they given the care required to insure the best quality of beet. To sum up there is not a single element lacking here for a successful beet-sugar manufactory.

"Tests made by different parties and at different times varied in some particulars. The sanguine report that some of the product goes as high as 20 per cent. of sugar, but it is safe to say that the average will be about 17 per cent. Though, according the The Champion, "the trusted chemist," to quote its own words, "of the Messrs. Spreckles has analyzed Chino beets and reports that they contained 19.33 crystallizable sugar with a co-efficient of 86.5 purity,—both far above the average in the most favored beet districts of Europe or America. Beet seed planted on the Chino dry land in May in but a single row and other unfavorable conditions produced beets that gave 14 per cent. of cane sugar." The beets will go about 18 tons to the acre on Chino lands under favorable conditions, valued at $5.04 per ton, (which was the average price at Watsonville for last year) the crop will prove very profitable, and greatly enhance the value of the land. Mr. Gird, the owner of the Chino ranch, is deeply interested in the subject, and other capitalists, notably the Oxnard Brothers and the Spreckles, are interested in the subject with a view to establishing a factory at this point. Indeed, it is said that the former have an option to put up the works, and investigations are now going on. The factory, if built, will give employment to a large number of hands, and use large quantities of beets during the beet season, necessitating an area of about 3,000 acres planted to sugar-beets.

"Our enterprising neighbors at Santa Ana have also been trying their hand. While there has been no attempt at growing sugar-beets on an extensive scale, the farmers of this favored region seem to be alive to the importance of this new industry, and they are ably seconded by the enterprising business men of Santa Ana. The board of trade has taken hold of the matter, and we look for substantial encouragement from this quarter. The analysis of beets sent some time ago to the sugar factory at Watsonville is as follows:

	No. of beets in sample.	Average weight in ounces.	Total solids.	Polarization.	Not sugar.	Co-efficient of purity.
Pet Greenwald	1	17¾	17.40	12.75	4.65	73.2
G. M. Doyle	3	24⅝	20.50	17.01	3.49	82.9
D. G. McClay	2	54	16.00	8.89	7.11	55.6
John Hassheider	2	21⅛	13.20	8.80	4.40	66.6
D. Edson Smith	2	13⅜	19.60	14.90	4.50	76.8
J. D. Colburn	2	36⅛	12.50	7.22	5.28	57.0
James H. Bett	2	23⅞	16.45	10.77	5.68	65.4
A. Melchert	2	17¾	19.00	15.15	4.85	74.5
F. A. Marks	1	30¾	12.60	8.30	4.50	66.0
Do	1	54½	12.90	7.75	5.15	60.0
A. Bacon	3	8⅝	16.10	11.80	4.29	73.3
O. W. Bill	2	42½	15.50	10.58	5.02	68.3
——— Hill	2	30¾	16.25	12.06	4.19	74.2

"The above demonstrates that the Santa Ana Valley is adapted to this plant. Though the analysis was below that of the Chino beet, yet it was very encouraging, and warrants future development. The business interests of the valley are using every legitimate means to foster and encourage beet cultivation.

"Since the foregoing there has been another analysis made showing a higher per cent. of saccharine matter that is very encouraging.

"Experiments have also been made in other portions of Southern California, all tending to show that the beet can be grown here and that it finds a congenial home in our climate."

EXPERIMENTS AT WATSONVILLE.

The Western Beet Sugar Factory at Watsonville has been in operation two years and apparently with favorable results. The officers of the company kindly furnished the Department with data respecting the season of 1888–'89, an abstract of which follows. A request from us for similar data for the season of 1889–'90 has not been complied with.

Recapitulation of the workings of the Western Beet Sugar Company's factory at Watsonville, Santa Cruz County, Cal., for the campaign ending December 19, 1888.

Sugar, freight from Watsonville to San Francisco		$2,936.55
Coal	total cost	17,267.00
Coke	do	1,658.93
Fuel oil	do	11,356.02
Wood	do	990.50
Lime rock	do	1,780.30
Sugar bags	do	1,740.34
Soda	do	12.39
Tallow	do	57.21
Expense, labor, etc		21,091.27
(Beets) incidentals		2,575.82
Cost of beets		71,055.89
		132,522.22
Which is the cost of manufacturing 1,640 tons sugar delivered free on board in San Francisco.		
We have received for 3,280,000 pounds sugar		162,454.70
Making cost of sugar $80.80 per ton of 2,000 pounds.		
Profit		29,932.48
Beets consumed	tons	14,077
Sugar produced	do	1,640
Men employed		135
Time of run	days	61
Beets, average polarization	per cent	14.60
Beets, average sugar recovered	do	11.65
Sugar, average polarization	do	95.40
Sugar, average price	per pound	5.64 cents
Beets, average price	per ton	$5.04

Manufacturing work at Alvarado.

No report has been received of the operations of the factory at Alvarado during the past season, and therefore I am not able to say whether or not the work was successfully conducted.

MISCELLANEOUS EXPERIMENTS AT THE DEPARTMENT.

Samples of beets were sent from various localities to the Department for analysis during the autumn of 1889. These beets were grown usually by persons who had no knowledge of the proper methods of agriculture as applied to the production of a beet rich in sugar, and hence it is not at all remarkable that many of them show a low content of sucrose. It must further be considered that the seeds were not in all cases of guarantied purity, and this would naturally lead to the production of many beets of low sugar content. On the contrary, the exceptionally high percentage of sucrose found in some samples shows very conclusively that there are many parts of this country where sugar beets of the highest grade can be produced. In the case of No. 6562 there is a phenomenally high percentage of sucrose, which probably was due to some adventitious circumstances with which we were not made acquainted. The table of analyses gives the percentage of juice expressed, the percentage of solids determined by actual drying, the percentage of sucrose in the juice, and the purity co-efficient. The samples are described as follows:

No.	From—	Variety.
6523	Ira Ford, Hastings, Nebr	Vilmorin.
6524	......do	Not given.
6525	......do	Do.
6527	Gustav Onker, Chapin, Ill	Do.
6528	......do	Do.
6529	......do	Do.
6530	Frank Burnham, Chapin, Ill	Do.
6531	Ira Ford, Hastings, Nebr	Do.
6532	......do	Lane's Imperial.
6533	The Empire Coal Company, Gilchrist, Ill	Not given.
6534	Rollin Orcutt, Harmony, Nebr	Vilmorin.
6535	D. Wendhuser, Pender, Nebr	Do.
6536	A. S. Darling, Alliance, Nebr	Lane's Imperial.
6552	Ira Ford, Hastings, Nebr	Do.
6553	......do	Do.
6554	......do	Vilmorin.
6555	W. C. Buderus, Sturgis, S. Dak	Alkali, white.
6556	......do	Sturgis, white.
6557	......do	Alkali, red.
6558	......do	Bair Butte, white.
6559	John Jenkins, Lincoln, Nebr	Lane's Imperial.
6560	......do	Vilmorin.
6561	......do	Do.
6562	......do	Do.
6563	......do	Do.
6564	......do	Do.
6565	......do	Do.
6566	......do	Do.
6567	......do	Not given.
6568	......do	Vilmorin.
6569	......do	Do.
6570	......do	Lane's Imperial.
6571	......do	Do.
6572	......do	Vilmorin.
6610	......do	Do.
6611	......do	Lane's Imperial.
6612	......do	Improved Imperial.
6615	Otto Herbich, Detroit, Mich	Not given.
6616	......do	Do.
6617	......do	Do.
6620	John Jenkins, Lincoln, Nebr	Lane's Imperial.
6622	R. E. Fleming, Wheatland, N. Dak	Not given.
6640	E. R. Johnson, Brady Island, Nebr	White Vilmorin.
6642	W. A. Anderson, Ord, Nebr	French white sugar beets.

Serial number.	Juice, expressed.	Total solids in the juice.	Sucrose in the juice.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
6523	67.52	9.55	5.70	59.69
6524	62.65	13.02	9.10	69.89
6525	62.02	13.02	9.10	74.50
6527	44.66	12.17	8.40	69.02
6528	52.94	14.02	9.50	67.76
6529	57.79	7.62	4.05	53.14
6530	59.54	11.32	7.10	62.72
6531	51.50	14.02	9.25	65.90
6532	61.83	13.77	9.75	70.80
6533	47.14	16.67	13.40	80.38
6534	44.65	16.02	12.50	78.02
6535	47.55	14.37	9.00	62.63
6536	51.83	17.60	12.30	69.88
6552	41.71	8.90	6.00	67.41
6553	46.95	17.07	12.50	73.22
6554	52.85	14.20	10.20	71.80
6555	47.95	16.20	10.75	66.35
6556	55.11	14.87	8.50	57.16
6557	44.11	19.37	13.55	69.95
6558	48.44	23.25	17.00	76.40
6559	48.23	14.00	9.35	66.78
6560	60.56	15.57	10.45	67.11
6561	38.31	18.26	13.50	74.17
6562	39.04	28.80	22.30	86.43
6563	45.39	18.35	13.50	73.56
6564	59.44	12.82	10.10	78.77
6565	57.74	13.07	9.00	68.85
6566	54.63	10.35	6.50	62.99
6567	....	16.20	13.50	83.33
6568	48.13	14.52	10.65	74.73
6569	55.66	6.92	3.55	51.44
6570	55.13	15.37	11.40	74.16
6571	46.89	14.65	10.40	70.98
6572	46.15	20.27	17.05	84.11
6610	45.69	17.48	12.70	72.65
6511	53.80	10.37	5.85	56.41
6612	45.95	17.30	12.90	74.56
6615	55.65	15.52	11.70	75.38
6616	54.71	18.05	14.15	78.38
6617	47.76	17.97	12.90	71.78
6620	48.81	15.20	12.00	78.94
6622	43.78	15.27	9.85	64.50
6640	....	23.03	16.40	....
6642	43.87	22.05	16.45	74.60

BEET-SUGAR INDUSTRY IN CANADA.*

"In order to encourage the beet-sugar industry in Canada it has been decided by the directors of the factories at Farnham to ask of the Government of Quebec a bounty of $1 per ton for all sugar-beets grown during the year 1890. In order to re-establish the beet-sugar industry at this point the proprietors offer the following inducements in the circular sent to farmers: The seed for planting the beets will be furnished gratis to cultivators; $4.50 per ton of 2,000 pounds will be paid for beets on board cars; the payment will be made on the delivery of each car-load of beets as soon as they are weighed; an advance of $10 per arpent will be made in the month of June to cultivators who have at least 3 arpents in beets; a second advance of $10 per arpent will be made in the month of July to all cultivators who, having properly thinned and hoed their beets, will have at least 25,000 plants left per arpent. Two premiums of $50 and $100 will be given for the best 3 arpents of beets."

*Journal des Fabricants de Sucre, March 19, 1890.

FACTORIES IN CANADA.*

"Of the three beet-sugar factories in the Province of Quebec only one worked this year. For various reasons the profits were not satisfactory. The success of this industry is possible, and the manufacture of sugar from beets will in time come to be considered the most remunerative of the country.

"The failures are due to two causes: First, bad management; second, want of working capital.

"The writer (Mr. Mussy) intends to renew his efforts, with French capital, and rent and work the Farnham factory. It is without doubt demonstrated that it is not possible to raise and deliver beets at the factory for less than $5 per ton. Each of the factories, Berthier and Farnham, has a working capacity of 15,000 tons. The writer suggests that American capitalists secure these factories where the farmers are already educated in beet-raising, in preference to building new works. These factories are located only a few hours from Boston and New York.

"The writer further states that in the vicinity of these factories many farmers are growing sugar-beets for their cattle. The Berthier factory worked this year. From an agricultural standpoint the campaign has been a great success, beets were purchased at $4 per ton and farmers were willing to contract for almost unlimited areas for next year. Unfortunately only 30 tons of roots have been worked per diem, while the capacity is 200 tons, and during the campaign of 1882 there was an average of 150 to 170 tons utilized per twenty-four hours."

THE BEET SUGAR INDUSTRY IN ENGLAND.

Dr. Schack-Sommer† contributes a paper setting forth the advantages which would accrue from the introduction of the beet-sugar industry into England. Four varieties of beets were grown by him from seeds obtained from Dr. Scheibler. The four varieties grown were:

1. Dippe's Richest Sugar-beet.
2. Dippe's Improved.
3. Dippe's Improved Red-headed.
4. Dippe's Improved Klein Wanzlebhen.

The fertilizer recommended for the beets is 200 to 300 pounds of nitrate of soda and from 400 to 600 pounds of superphosphate per acre. It is recommended to plow the soil 14 to 15 inches deep.

Experiments were made at two localities, one on the farm of Mr. John Ennis in Springwood, Ireland, and the other on the farm of Mr. John Gibbonsmin Wavertree, near Liverpool. An analysis of beets made on

*Abstract of a letter to the editor of the Sugar Beet, from A. Mussy. From "The Sugar Cane," February 1, 1890.

†Journal of the Society of Chemical Industry, February 28, 1890.

the 26th of September at the two stations, showed at the English station the following percentages of sugar: 15, 15.6, 14.7, 14.2; and at the Irish station, 16.7, 17, 18.2, 16.8. On the 10th of October another set of analyses was made at the two stations with the following results: At the English station, the percentages were 16.5, 17, 16.7, 16.4, and at the Irish station 18.2, 17.5, 17.2, 18.8.

The apparatus invented by Meyer and Buettner for drying the sliced beets is also described and it is claimed that with this apparatus it is possible to dry 225,000 kilograms of sliced beets per day at a cost of 8 cents per 100 pounds. In regard to the quantity obtained per acre at the English station the yield was 42 tons and 19 cwt.

BEET SUGAR IN THE NORTHWEST.

POINTS FOR CONSIDERATION WITH REGARD TO THE INTRODUCTION OF THE SUGAR-BEET AND THE MANUFACTURE OF BEET-SUGAR IN THE NORTHWEST AS COMPARED WITH THE BEET-SUGAR PRODUCING COUNTRIES OF EUROPE, BY J. D. FREDERICKSEN.*

"1. *Climate.*—In Europe the northern part of the temperate zone affords the most favorable conditions for the growth of the sugar-beet and the development of a pure juice from which the sugar is easily extracted. The northern part of Germany, Prussian Saxony, Brunswick, and Hanover; Denmark and the southern and middle sections of Sweden; Belgium, Holland, the northern departments of France; Bohemia and a section in the middle of Russia, all produce beets from which sugar can profitably be manufactured. Sections with complete inland climate seem to produce richer sugar-beets than those with coast climate. In northern Germany and certain parts of Russia and Sweden the beet is generally richer in sugar than in France, Belgium, Holland, or Denmark, the latter countries being more exposed to the sea. In England, where the climate is moist and temperate all the year round, the beets grow bulky but poor in sugar, and there the beet-sugar industry has proved a complete failure.

"As to Denmark the climate is not so favorable to the development of sugar in the beets as it might be. The spring is rather dry, so that it is hard to get the plants started, and the fall is so wet that there is a danger for the beets to set flesh at the expense of the quality of the juice. For the same reason the harvest is difficult. Still the industry is flourishing, so that the climate may not be called bad.

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* McMurtrie, *op. cit.* pp. 275, *et seq.*

"The following table shows the average temperature and rain-fall at Copenhagen, in Denmark, and in Minnesota:

Months.	Minnesota.		Denmark.	
	Temperature.	Rain.	Temperature (82 years).	Rain (44 years).
	Fahr.	*Inches.*	*Fahr.*	*Inches.*
January	15.85	.49	29.84	1.74
February	14.40	1.07	30.92	1.52
March	23.66	2.24	33.80	1.56
April	37.52	.95	42.08	1.46
May	62.24	1.65	51.62	1.49
June	68.70	11.67	59.90	2.12
July	74.72	1.94	63.14	2,30
August	70.54	3.90	62.24	2.48
September	60.95	5.76	56.12	2.18
October	49.36	3.21	47.84	2.17
November	28.72	1.90	38.84	2.04
December	18.81	.72	33.80	1.69
Total	43.62	35.50	45.84	22.75

"Comparing these figures, it would suggest itself that the excessive rain-fall in Minnesota in June might favor the development of the young beets, but at the same time make it very troublesome to perform the work of harrowing and hoeing to keep the land clean from weeds. The months of August, September, and October also seem rather moist, making it possible that too much inorganic matter may enter the juice at the time when the beets get ripe. Still, when falling in heavy showers at long intervals, as it probably does in Minnesota, the rain is neither likely to influence the beets nor to bother the harvest in the same way as when coming down gradually at short intervals. More water will evaporate from the soil, and therefore more rain is needed in Minnesota than in Denmark on account of the higher temperature of the former. According to another account the fall of rain in Minnesota is as follows:

Seasons.	Minneapolis.	Duluth.	Breckinridge.	Pembina.	New Ulm.
Winter	3.105	2.160	4.980	2.750	2.260
Spring	7.960	6.480	6.250	2.450	6.300
Summer	16.304	20.850	14.150	7.250	7.020
Fall	5.108	8.060	3.580	6.910	9.280
Annual	32.456	37.556	28.960	19.360	24.860

"With such extraordinary differences within the same State it would seem likely that some sections, at least, may be favored with the proper climate for a successful cultivation of the sugar-beet. The temperature of the summer does not seem excessively high, for even far south on the continent of Europe the beet is grown successfully, and just in those of the above sections where the beets are richest in sugar the summer heat is comparatively high.

"2. *Soil.*—The proper soil for the sugar-beet is neither too heavy (clayish) nor too light (sand), nor containing too much organic matter. A well cultivated, rich, and deep soil, that would produce a good crop of barley for malt, is well adapted for the sugar-beet. New and rich land, that in a crop of cereals would develop the straw at the expense of the seed, would make a bulky crop of beets, but they would be poor in sugar and rich in non-sugar, detrimental to the extraction of the former from the juice. Land of old cultivation, made rich by continued plowing and manuring, is better than newly broken land. Therefore, without knowing from personal experience, one would imagine the soil of Illinois to be better adapted to the sugar-beet than that of Minnesota. The land should be well drained, either by nature or by pipes laid deep in the ground, allowing no water to remain on the surface at any time.

"The limits for the physical condition of the soil are, however, very wide, for we have grown rich sugar-beets on comparatively heavy and on comparatively light soil, the former being made porous by deep drainage and intense stirring with steam-plow and cultivator But, whether heavy or light, only land in a state of high cultivation could produce beets rich in sugar.

"3. *Labor.*—One of the worst drawbacks to the successful introduction of the sugar beet in the northwest would seem to be the labor question. Even with the advantage of the best implements to stir the land, thin and clean the ridges, and gather the crop, the hand-labor needed to grow sugar-beets is considerable. Wages being about three times as high in the northwest as in Denmark, this would increase the expenses at a great rate. Supposing one hand to be needed for 3 acres of land for four months, about thirty days' work would be necessary to cultivate 1 acre. Supposing 1 acre to yield 15 tons of beets or 2,400 pounds of sugar (8 per cent.), thirty days' work, at $1.50 a day, would make $45 an acre, or $3 per ton of beets, or 18¾ cents per hundred-weight of sugar, while in Denmark, at 50 cents a day, the labor would only amount to one-third of these expenses. And supposing the product could bear such expenses, would it be possible to gather a sufficient number of hands so as to grow 1,500 acres of beets within the limit for the area of one sugar factory? For it is a deplorable fact that, at the present development of the industry, sugar can not be manufactured from beets on a small scale, but must be produced in large establishments, which require the raw material from a large number of acres. And, on account of the bulky quality of the beets, they can not bear long transportation, and must therefore be grown within a certain comparatively narrow distance from the factory. Again, during the manufacturing season, which only lasts about four or five months, the factory would employ a number of hands who, after all of the beets have been disposed of, would have to look for employment elsewhere. While at the time between the clearing of the beet land and the harvesting of the beets the regular harvest of the cerials might give employment to the beet hands, would the forests of Minnesota or other industry dispose of the laboring hands during winter and early spring, until the beet field again might need them? Sugar beets should not be attended to only when the other work of the farm is done and there is nothing else to do, but should be worked when they need working. Without independent labor at the proper time their cultivation always proves a failure. So also should the manufacture of sugar begin when the beets are ripe and contain most sugar, and it should be continued energetically as long as any beets are left, in order to dispose of the whole crop before too much sugar is lost, for every day after the beets are ripe they grow poorer in sugar. Therefore laboring hands must be at disposal at any time when they are wanted, independent of other work that might need them.

"In the factory the high rate of labor in the the Northwest would add considerably to the expenses; while in the beet field where, in Denmark, female hands are employed in a great measure, the labor would probably be three times higher in Minnesota than in the old country, the manufacturing labor expenses would, no boubt, be twice as high in Minnesota as in Denmark. In the latter country the labor expenses in the factory amount to $1.15 per ton of beets, or about .72 cent per pound of sugar.

"4. *Other expenses.*—Quite different is the case with regard to other expenses than laboring. The cheapness of the land in the Northwest as compared with rich land in the old country will, no doubt, do much towards reducing the expenses of the growing of beets in Minnesota. In Denmark the rent for rich land amounts to $7 to $8 an acre. In Germany as much as $16 per acre is paid yearly for a rentage lasting ten or twenty years. In the Northwest, improved land could probably be had for less than half the rent in Denmark.

"In the factory coal plays a prominent part among the expenses other than labor. In Denmark this item amounts to $1.20 per ton of beets or .75 cent per pound of sugar—the price for coal being $6 per ton. This price being reduced to $2 per ton, the expense for fuel would be 40 cents per ton of beets or .25 cent per pound of sugar only.

"5. *Duty.*—In the old country the duty paid to the government by the manufacturers makes a heavy reduction of the profit realized by the production. In Germany the duty is laid on the beets, being raised gradually from 1836, when it was only one-fourth silver groschen per hundred weight (11 cents per ton) of beets, to the present time, when it amounts to 9 silver groschen per 100 pounds ($4 per ton). This is, in a great measure, the reason why in Germany the manufacture of beet sugar is developed to such admirable perfection as is the case. The more sugar that could be gained from the beets, the less the duty drew on the profit of the manufacturer, for the duty on 1 ton of beets remained the same whether 6 or 10 per cent. of sugar were extracted.

All the efforts of the farmer and the manufacturer had the aim to produce much sugar from a certain weight of beets, not to produce much sugar from an acre of land. Therefore the quantitative yield of beets was neglected, while beets were produced which yielded as much as 10 per cent. of sugar.

"In Sweden the same system is adopted. In Belgium and partly in Holland the duty is calculated on the basis of the quantity and richness of the juice extracted from the beets. In France and in Denmark the duty is laid on the sugar produced. For this reason it is in these countries the aim of the producer to get the largest yield of sugar from an acre, only provided that it can be profitably extracted. Therefore the yield of beets is larger, but their contents of sugar less than in Germany. In Denmark the duty is equal to that on imported sugar, amounting to 2.16 cents per pound of raw sugar (below No. 18 Dutch standard), or about $3.45 per ton of beets. The duty in this country being about 3.5 cents for average raw sugar, this item would amount to $5.60 per ton of beets in favor of the manufacturer, provided 8 per cent. of raw sugar can be extracted (besides the molasses).

Summing up these items the following figures are arrived at in favor or in disfavor of the sugar industry in Minnesota, as compared with Denmark, provided 8 per cent. of sugar is realized in both countries:

	Extra expenses in Minnesota.		Savings in Minnesota.	
	Per ton of beets.	Per pound of sugar.	Per ton of beets.	Per pound of sugar.
Labor in field	$2.00	$0.0125		
Labor in factory	1.15	72		
Rent			$0.23	$0.0014
Fuel			.80	.0050
Duty			5.60	.0350
	3.15	197	6.63	.0414

"Deducting the extra expenses from the savings, we arrive at the following real savings in favor of Minnesota:

Per ton of beets	$3.48
Per pound of sugar	2.17

"But the whole calculation depends upon the question, can beets be grown in Minnesota which will yield 8 per cent. of sugar? The most careful study of tables of rainfall and temperature, and of analysis of the soil, can not decide the question. The only way is to try. Seed of rich sugar beets should be distributed to intelligent farmers throughout the Northwest, accompanied by directions how to grow beets. The farmers who undertake to carefully make the experiments should be requested to return an average sample of the crop, describing the soil in which the beets are grown, and the treatment of it; the fruits which the land bore in previous years; the manure, if any, that was used;

the time in which the manure and the seed were sown, and at which the thinning out, the harrowings and hoeings, and the harvest were performed; the yield per acre, etc. The samples should be analyzed, not only for sugar (and especially that kind of sugar which would turn the polarized light to the right, and which would crystallize), but also for organic and inorganic non-sugar. Such material for one year would already afford valuable suggestions, and, carried on for several years, such experiments would justify a decided opinion about the propriety of the introduction of the industry. To start a large and expensive factory without such foundation would be to run a great risk, and to establish small and cheap factories would always prove a failure.

"As to the plan for establishing sugar factories, several systems prevail in Europe. One is the co-operative, very much like the system of cheese factories and creameries in certain sections of this country. The farmers in a section intending to establish a sugar factory form a joint stock company, and are bound to deliver to the factory the beet crop of a certain number of acres for each share in their possession in Brunswick generally 8 acres for each share of $100).

"For the last ten years the sugar factories have become very expensive, being profitable only when very large, and when furnished with the latest inventions. Therefore, the farmers could not afford to build their own factories if it were not for large stock companies which undertake to build and furnish factories for the farmers, leaving the greater part of the cost at low interest to be paid off gradually, against mortgage in the buildings. This plan does not work well in a country where the industry is new, and, though it is no doubt best of all, it can not be introduced until the beet sugar industry has proved an unquestionable success, and is known to the people as a safe thing to invest in.

"Another plan is for a stock company to establish a factory, buying the beets from the farmers, and return the refuse (pulp) to be consumed on the land, so as not to exhaust the latter. It is, however, not an easy task to induce the farmers at once to grow an area with beets large enough to furnish a factory with sufficient raw material of good quality for a successful starting. It takes time and experience to learn how to grow rich sugar-beets; the best way to learn it is to get direct interest in the profit. Therefore such concerns who build factories, intending to buy the beets in a section where the industry is not previously known, are generally forced to grow a large portion of the beets themselves, by establishing some kind of bonanza farms, or by renting suitable land for the purpose, returning it to the farmers after the crop has been gathered. In fact, this is the only way to secure within reasonable time enough of good raw material, until, by and by, the farmers are educated for the task.

"In Denmark the beet-sugar industry was introduced in 1873, when it had been ascertained by experiments during several years that sufficiently rich sugar-beets could be grown. Two factories were started, one by an old concern that previously commanded the whole sugar-refining business of the country, the other by a new stock company prominently made up of landed proprietors. The former company built a large factory in a fertile section occupied by intelligent farmers, who, it was thought, should furnish the beets. The factory was capable of working up 12,500 tons of beets a year. The first year only 2,500 tons of poor beets were received, and the second year proved but little better. Then the managers were convinced of the necessity of adding farming to their business, and bought a farm of 300 acres, to manage which an expert was engaged. Another year more land was added to the farm, and suitable fields were rented for one year and grown with beets by the manufacturers. On these lands rich sugar-beets were grown. In the meantime the farmers learned how to grow the beets, and the quantity received at the factory increased yearly, until now sufficient raw material is furnished so as to run the factory profitably. Large amounts of money were lost during the first five years. The business seemed condemned to failure, but the managers succeeded in keeping it going until the balance turned, and now the factory is flourishing.

"The other company went at once to work and rented for twenty years three large farms, of 2,000 acres of land in all, every acre of which was in a state of high cultivation and well drained. This land was divided into four fields and sown successively with wheat, beets, barley, and clover, so that every fourth year beets were grown on the same land. Steam-plows and first-class machinery were introduced. The factory was built so as to work up 7,500 to 10,000 tons of beets a year. Besides those grown on the 500 acres of the company, more beets were grown by the company on land rented yearly and being returned to the farmers after use, and as many as possible were bought. In this way the company succeeded in gathering 6,000 tons of tolerably rich beets the very first year, sufficient to make a rather successful start. The factory being built at a time when all materials were as expensive as ever; the price of sugar falling about 30 per cent.; hard competition being brought to bear from the sugar refiners; an excessive duty even higher than that on imported sugar * being at once enforced as soon as the manufacture was started; and finally entering the time of universal financial depression, commanding insufficient capital, the company could, however, not carry the work through, and failed in 1876. A new company took the matter in hand, and carrying on the business on the same principle as it was hitherto managed, have succeeded in making it pay well.

"Having passed through extraordinary difficulties, the beet-sugar industry in Denmark is now successful. But though a handsome profit is realized by the manufacturers, it is nothing compared with the indirect profit which is the result of the improvement of the land where

* The duty at once laid on the manufacture of beet sugar in Denmark was a few years later acknowledged by the government to be higher than that on imported sugar, and was reduced accordingly. In no other country in the world has this industry suffered an immediate imposure of duty, time being everywhere else allowed for the industry to develop and acquire stability.

beets have been grown. The influence on the land of the deep and thorough cultivation, and the use of fertilizers, which go hand in hand with the growth of the sugar-beet, of the beet itself by opening and manuring the soil, and of the stable manure which is produced by this system, is simply wonderful. All other crops are increased and their quality improved. On such land as would previously produce only common barley, a highly praised malting grain is now raised, which brings far better price than the old product. Those farmers who at first looked suspiciously on the new industry are now quite enthusiastic in favor of it, and several factories are about to be built this year."

USE AND TREATMENT OF PULPS.

PRESERVATION OF DIFFUSION PULPS IN SILOS.

Instead of feeding the diffusion pulps at once they may be kept in silos for future use. A silo suitable for this purpose is described by Minangoin.* In silos made of earth there is a considerable loss of material on account of mixture of the earth with the pulp. On the other hand, the cost of silos constructed in masonry is very great. The pressure of the pulp is so great that such silos must have an unusual thickness to withstand it. A cheaper form of silo is therefore indispensable for farmers' use.

A silo made of heavy planks appears best suited for preserving the pulp.

The silo described by Minangoin is about 70 feet long and 6 feet wide. The bottom is made of a layer of stone, but without cement. The surface is slightly raised in the center to permit of the outflow of liquid on both sides. A ditch surrounding the silo is disposed in such a manner as to properly dispose of the drainage water. The boards of the silo are supported by oak posts 4 inches square, deeply set in the earth, and placed at distances of about 5 feet apart. These posts are connected from side to side by iron rods one-half inch in diameter.

Between each plank in the sides and ends of the silo is left a space, 1 inch, to facilitate the drainage of the pulps. The planks should have a width of about 1 foot. For convenience in filling, as well as for use, it is well to divide the silo into parts by running a partition from post to post. By leaving out the iron rods until each partition is filled and filling the farther part first the charge may be brought directly into the silo from its open end. The silo should be 5 feet high at the sides and 8 feet in the center, and will then contain over 300 cubic yards of pulp. The pulps are preserved perfectly. The pulp gradually acquires a remarkable dryness and density, and there is no waste either at sides or bottom. It is not necessary to furnish it with a cover.

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*Sucrerie Indigène, March 25, 1890, page 282.

PRESERVATION OF BEET PULP. *

"On well-organized sugar-beet plantations there should be special arrangements for keeping refuse pulp during the winter, a period when green fodder (so essential to the health of live.stock) is difficult to procure.

"In previous issues of The Sugar Beet we mentioned experiments made from year to year in pulp preservation, and how this refuse may

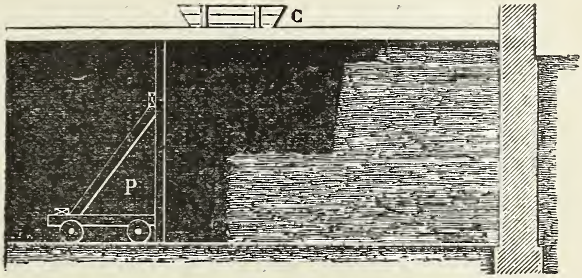

FIG. 44.—Vertical section of silo for beet pulp.

be kept in good condition by a liberal use of salt, etc. The greatest difficulty to contend with is the water retained by the pulp; fermentation soon follows. The organic transformations are not objectionable if

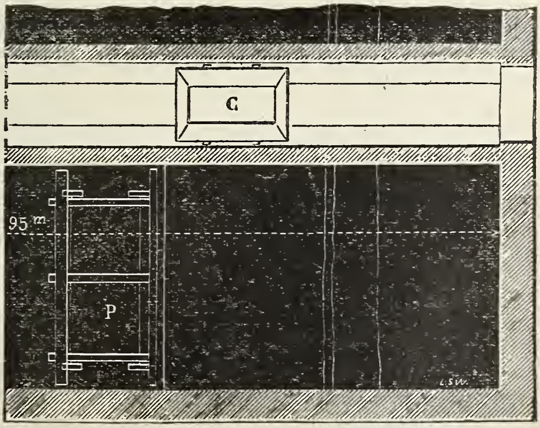

FIG. 45.—Horizontal section of silo for beet pulp.

arrested at the proper moment; on the contrary, live-stock seems to eat with considerable avidity pulp having slightly soured, or of acetic taste.

The Sugar Beet, August, 1888. *

If the cattle to be fed are numerous, their daily consumption may be equal to the supply; silos under such circumstances are unnecessary. On the other hand, during the one hundred days representing an ordinary campaign of beet-sugar factories, the fattening results can not be satisfactorily obtained, because the period is too limited. From a general point of view pulp silos may be a source of considerable revenue to all interested.

"At the Ferme de la Briche (France) may be seen a silo of 4,000 cubic meters capacity used for distillery pulp. The refuse is carried from mash tubs in cars C, Figs. 44 and 45, in which it is mixed with chopped straw, hay, etc. A movable partition P (19.68 by 11.48 feet), having the exact dimensions of the silo's cross-section, is mounted on wheels and placed a short distance from the end wall. The intervening space is filled with closely-packed pulp, thus preventing fermentation, and a layer of 10 inches earth covers the top. The partition is moved backward, and the foregoing operations repeated. It is said that beet pulp, under such conditions, will keep for years; it is taken from the silo in vertical slices."

DRYING OF THE PULPS FOR PRESERVATION FOR FEEDING PURPOSES.

In an address made at the agricultural association of the Province of Hanover, Mr. Koester described the process of the drying of pulp for the purpose of preserving it for cattle food. This new feeding stuff is known by the name of 'dried diffusion pulp,' and is being largely discussed in France lately. Very little is known in regard to it by the farmers themselves up to the present time. The cost of the drying plant and the expenses of the process are great and there is much doubt whether any profit results from it. Some of the data in regard to the matter have been collected by Mr. Koester. He says if he had received, during the present year, the whole of his pulp in the humid state he would have been compelled to transport 57,000 quintals. Of this quantity 9,000 would have been consumed during the campaign, and 48,000 would have been preserved. If these 48,000 quintals had been dried the expense of placing them in silos, and the transportation of them from the silos to the feeding-stalls, would have been saved. This extra expense is estimated to be from 2.5 to 3 pfennigs per quintal, or, expressed as a mean of the whole cost, 1,330 marks. The drying of 48,000 quintals of pulp would have cost 4,320 marks; deducting from the above the 1,330 marks for the expense of preserving the wet pulp, there would remain a net expense of 3,000 marks for the desiccation. It is estimated that the undried pulp, in keeping, lose in all about one-third of its nutritive value, which would be equivalent to 16,000 quintals. If, however, these 16,000 quintals had been dried they would have yielded 1,880 quintals of dried pulp. It is estimated that the feeding value of 1,880 quintals of dried pulp is equal to 7,500 marks;

deducting from this sum the net expense of desiccating, viz, 3,000 marks, there would have resulted a net gain on the whole mass of 4,500 marks. One factory at Rethen worked up nine times as many beets as were furnished by Mr. Koester; they would, therefore, have realized 40,000 marks profit by drying all of their pulp. The process of drying the pulp employed was that of Buttner and Meyer. The dried pulp furnishes a food which is preserved indefinitely without alteration, provided it is put in a dry place. According to Wolff it contains:

	Per cent.
Water	11.6
Ash	7.1
Crude protein (of which digestible 4.1 per cent.)	6.6
Fiber (of which digestible 16. per cent.)	19.3
Non-nitrogen matters (of which digestible 45.9 per cent.)	54.8
Fats (of which digestible .6 per cent.)	.6

It is therefore a nutriment especially rich in carbohydrates, but one which should be supplemented by some food furnishing the missing qualities; for instance, some food rich in nitrogen.

It is not necessary to saturate the dried pulp with water before giving it to cattle. Animals consume the pulp willingly in the dried state, and the experiments of Professor Maercker have shown that the nutritive effect is at least as good with all kinds of animals as when fed the moist pulp. Mr. Koester has had equal success in feeding this food to milch cows, to cattle preparing for the market, and to sheep. He has even fed it to calves of four months old, and young lambs, who take it willingly. It has also been given to horses with success, in the proportion of from 5 to 6 pounds for each one. We seem, therefore, to have in this dried pulp a nutriment capable of any application, and which appears destined not only to play a grand role in the alimentation of cattle, but also to render superfluous many other kinds of forage, and to give an opportunity to use to a considerable extent such materials as cotton-seed and linseed cakes rich in nitrogen matter. In the case of five beeves which were fattened, they received, beisde straw and moist pulp, a mixture of dried pulp, peanut cakes, sesame cakes, and cotton seed meal. During four weeks in which the effect was noted, the animals increased at the rate of from 2 to 3 pounds per day.*

FEEDING EXPERIMENTS WITH THE LEAVES AND DIFFUSED PULP OF BEETS. †

At the general meeting of the Central Agricultural Society of the Duchy of Brunswick, February 25, 1890, Professor Maerker gave an address upon certain recent feeding experiments, which were of special interest to the sugar interests, as the experiments treated of the values

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† By Professor Maerker, Halle.

of beet leaves, also of the pulp, after diffusion, both in the moist and dry conditions.

Professor Maerker commenced by stating that the tables of Wolff, which allow 3 pounds of nitrogenous food matter per 2,500 pounds of the living weight of the animal, are no longer to be accepted in view of existing standards of cattle feeding. It is more advantageous to raise the allowance of nitrogenous matters, and gradually, to the relation of 5 pounds per 2,500 pounds of living weight. Contrary to the increasing of the proportion of non-nitrogenous matters, as advised by the Wolff tables, it may be a detriment to the animal system, and, economically, an actual disadvantage.

Experiments were conducted in order to ascertain the approximate value of beet pulp after the act of diffusion. Three classes of experiment animals were fed respectively, with 50, 75, and 100 pounds of diffused pulp, deductions being made in the other foods fed to the animals in proportion to the respective increments of nitrogenous matter contained in the three rations specified. An increase was observed in the volume of milk given by the animals of from 12.6 and 12.7 quarts respectively to 13.2 and 14.2 quarts without any depreciation of the quality of the milk being observed. On the other hand, not any increase in the living weight of the animals had occurred, and in the examples where 100 pounds of the pulp had been served to the cattle an actual diminution of weight had taken place. The maximum quantities of the diffusion pulp which it appears advisable to serve to the different classes of animals are as follows: To cows in milk, 40 pounds; feeding oxen, 90 pounds; and to feeding sheep, 5 pounds. It has been further observed that the distillery residues may be served to cattle in double the quantity of the diffusion pulp providing that the animals receive the former in a warm state. As a result of this observation artificial preparations of potatoes and cotton-seed meal have been made and fed to cattle in the warm state, and with a clear gain of 4 cents per cow per day.

There is one other source of food for cattle which has not received the attention which it deserves: That is the leaves of the beet. At present those materials are merely browsed by sheep on the land where they lie, and the greater part is trodden into the soil. In some instances the leaves are mixed with the diffusion pulp and preserved in silos, or the leaves are preserved in the silo alone. Professor Maerker has made several experiments at Siegersleben for the purpose of determining the food value of the beet leaves and he proposes to continue his experiments during this year.

He gave to ten sheep 125 pounds of beet leaves in the form of ensilage, and to ten other sheep 90 pounds of diffusion pulp, taking care that the other foods given to the animals contained the same amounts of nitrogenous matters. The increase in weight of the ten sheep fed with beet leaves was 3.4 pounds, and of the ten sheep fed on diffusion pulp, 4.1 pounds, showing an apparent advantage in favor of the latter of 23 per cent. From the stand-point of economy, however, the case was otherwise: The gain of the ten sheep fed on diffusion pulp was 4.6 cents per head, whilst the money value of the increase of the ten sheep fed on the beet leaves was 6.4 cents per head. It is thus seen that the greatest increase in weight may not essentially represent the greatest gain.

In certain other experiments the foods already specified were supplemented with respectively ⅓ pound of cattle food prepared from poppy seed and 1 pound of rice meal for each ten sheep, when an increase of weight was observed of 4.1 pounds and a gain of 10 cents per head.

In feeding the ten sheep with beet leaves, allowing the animals to consume what they liked, 169 pounds were consumed without damage to health, and yielding an increase of weight of from 4.17 to 4.8 pounds and a money value of from 11 to 14 cents.

In the leaves of the beet there is thus found an excellent article of diet for the feeding of cattle. The leaves may be valued at from 25 to 30 cents per 250 pounds. If it be calculated that one acre will yield varying from 12,500 to 25,000 pounds, that amount would represent a food value per acre of from $25 to $60.

Professor Maerker has also conducted comparative experiments with diffusion pulp in the humid and dry states, respectively, and has found the results to be demonstratively in favor of the latter. The pulp in the dry state contained from 55 to 60 per cent. of non-nitrogenous matter and 6½ to 7 per cent. of nitrogenous matter, 85 per cent. of the latter being digestible, whilst only 75 per cent. of the nitrogenous matter in the humid state becomes digested.

The cost of purchase of the diffusion pulp in the dry state may be calculated as follows:

	Cents.
Average price of 250 pounds of dry pulp	12
20 per cent. loss of material in depot	2
Cost of transport	1
Cost of ensilage (preservation)	2
	17

The feeding of cattle with the material in the moist state is not only inconvenient but conducive to certain forms of disease.

The best process for the drying of the pulp is that adopted by Messrs. Büttner and Meyer. These gentlemen have guarantied the cost of drying shall not exceed 2½ cents per 250 pounds of pulp. Hadmersleben has reduced the cost of desiccation to 2 cents, and expects to reduce it still further to 1½ cents per 250 pounds.

The experiments were carried out as follows: On the one hand the moist pulp was fed to the cattle with hay or grass and a good portion of the cattle cake. On the other hand the animals received the dry pulp and a portion of cattle cake less rich in nitrogen. It has been established that the quantity of milk obtained was on the average the same from the dry as from the moist pulp, and the cost of feeding with the dry pulp was 2 cents per head per day less with the dry than with the moist pulp. In taking all the conditions into account it is estimated that the advantage in feeding cattle with dry pulp over the moist is on an average about $14 per head. About 20 pounds of the dry pulp is equal to 130 pounds in the moist state.

The cultivators should endeavor to get the sugar manufacturers to commence the system of desiccating the pulp, either alone or in agreement with the cultivators, in order that a large proportion of that feeding material which at present is allowed to waste may be wholly utilized in the feeding of cattle.

MANUFACTURE OF SUGAR.

The process of the manufacture of sugar from the sugar-beet is one which interests the agriculturist only from secondary considerations and for this reason will be treated of in this bulletin in the briefest possible manner to give an intelligent idea of its methods. The process of manufacture is no longer an experiment but a positive method, from which, with beets of a given richness, a definite output of sugar can be calculated.

The beets, having been properly harvested and delivered to the factory, the general process of manufacture is as follows:

The beets are first conveyed to washing-tanks provided with suitable apparatus for keeping them in motion and transferring them toward the end from which the fresh water enters, in order that the whole of the adhering soil, together with any sand and pebbles, may be completely removed. By a suitable elevator, the beets are next taken to a point above the center of the battery, whence they are dropped into a slicing apparatus. This apparatus is provided with knives with serrated edges, by which the beets are sliced into pieces of greater or less length and of small thickness, so that when placed in the cells of the battery they will not lie so closely together as to prevent the circulation of the diffusion juices. The slices, commonly called cossettes, next pass into the diffusion battery in which the sugar is extracted in the usual way. The extracted cossettes are carried through a press by which a portion of the water is removed, and they are then in suitable condition for use as cattle food. The diffusion juices are carried to carbonatation or saturation tanks, where they are treated with from 2 to 3 per cent. of their weight of lime and afterward with carbonic acid until nearly all of the lime is precipitated. The slightly alkaline juices are next passed through filter presses by which the percipitated lime and other matter are removed. The juices pass next to a second set of carbonatation tanks in which they undergo a treatment in each particular similar to the one just mentioned, except that the quantity of lime added to the second saturation is very small as compared with that of the first. The refiltered juices from the second saturation are carried to the multiple effect vacuum-pan and reduced to the condition of sirup. The sirups are taken into the vacuum strike pan and reduced to sugar called masse cuite, containing from 6 to 10 per cent. of water. The uncrystallized sirups together with the water are separated from the sugar by the centrifugals, and form the molasses. The molasses is either reboiled and a second crop of crystals obtained, or is treated in various ways for separating the sugar which it still contains. One of these methods which has come into general use is known as the Steffen process, and is described in detail further on. Another method consists in separating the salts which prevent the crystallization of the sugar by the process of osmosis. A third method consists in the use of strontium salts for the separation instead of lime salts as in the Steffen process; or, finally, the molasses may be subjected to fermentation and distillation and the sugar therein contained thus converted into alcohol.

The above is the general method used for the manufacture of raw sugar. If refined sugar is to be made the juices and sirups are passed over bone-black to decolorize them and the crystals are washed in the centrifugal in order to make them perfectly white. Another method of purifying the crystals consists in washing them with sirups of varying degrees of consistency until all the molasses adhering thereto is washed away. For the details of the various processes with the exception of the Steffen process, which is given further on, standard works on beet-sugar manufacture may be consulted.

The following observations on the manufacture of beet sugar are taken from Mr. Spencer's report in Bulletin No. 5, of the Chemical Division, Department of Agriculture, pages 107, *et seq.*

"EXTRACTION OF THE JUICE.

"The most usual method for extracting the juice from the beet is by diffusion. This process has been so successful that now but comparatively few sugar-houses employ presses, either hydraulic or continuous.

"Diffusion batteries may be divided into two classes:

"(1) The ordinary, consisting of a number of cells.

"(2) The continuous, having but one cell. The first may be divided into (1) battery in line, (2) circular battery.

"The ordinary diffusion battery is composed of several cells, usually twelve in number. They are so arranged that as soon as one cell or diffuser is charged with beet cuttings it is closed and warm water forced into it. The water takes up a portion of the sugar and then enters a second diffuser charged with fresh cuttings or *cossettes*.* This operation is repeated, until the juice from the first diffuser, having passed through a certain number of cells, leaves the last heavily charged with sugar.

"In working a diffusion battery, one diffuser is being charged and a second emptied while the rest of the battery is under pressure.

"The arrangement of a battery, whether in a line, a double line, or a circle, depends quite often upon the space at the disposal of the sugar manufacturer. The circular arrangement requires a higher building

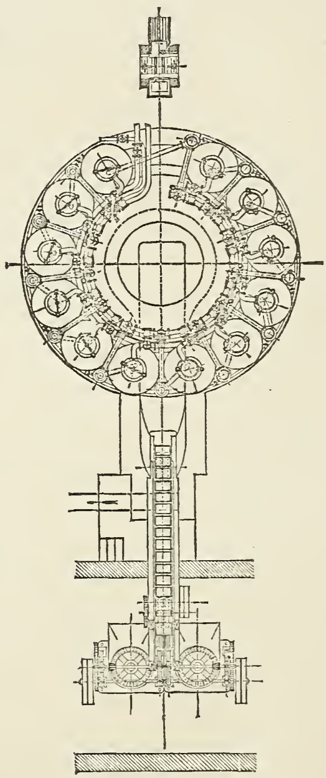

FIG. 46.

owing to the position of the slicing machines, but nevertheless it is usually considered preferable to a line battery. Among the special advantages of a circular battery is the economy of labor. Another advantage, and quite an important one, is that all the diffusers are under the immediate control of the workman in charge. The beet slicer is placed above the battery, a swinging funnel conducting the cossettes

*Cossettes in French, Schnitzel in German.

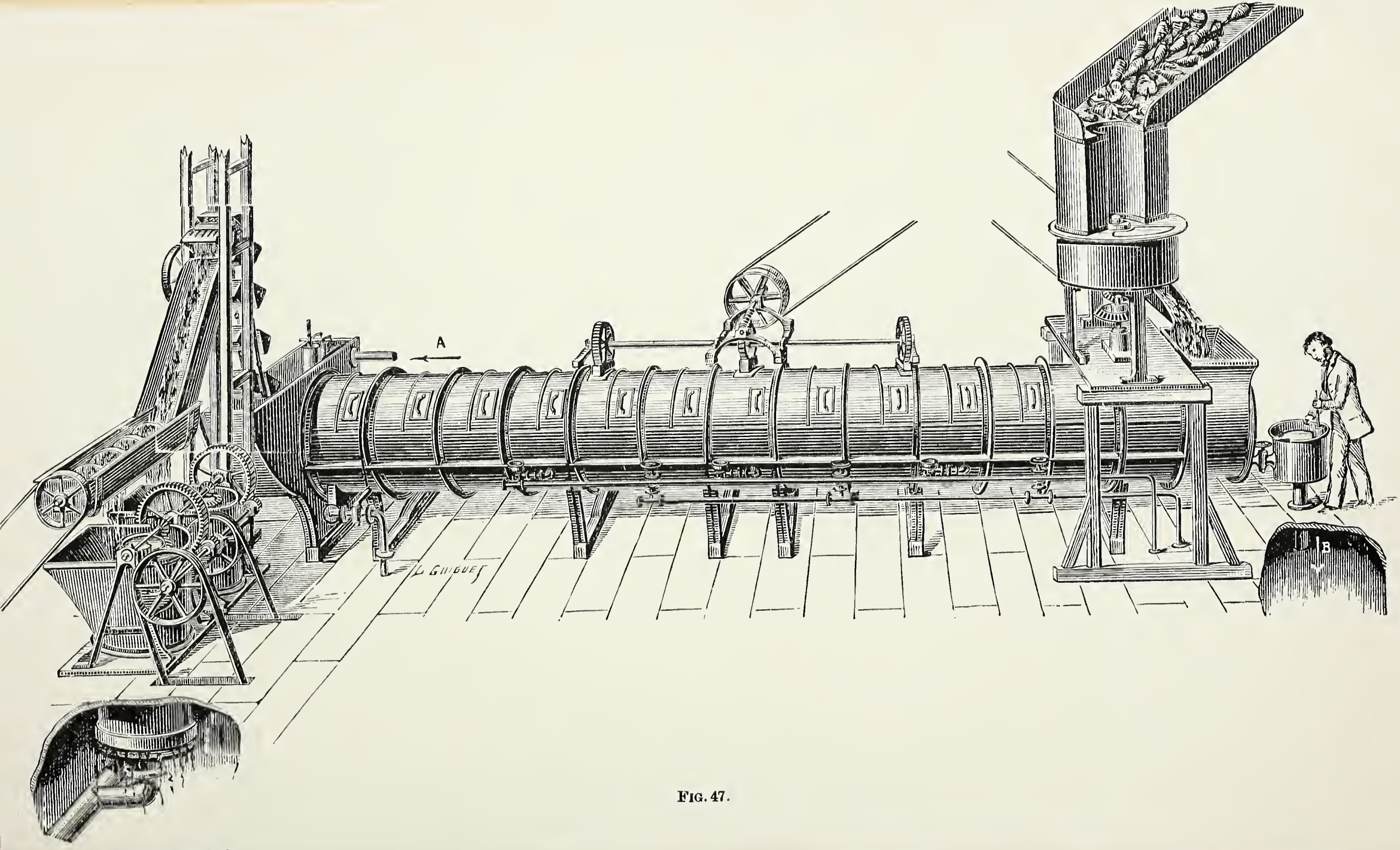

FIG. 47.

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into the diffusers. The exhausted cossettes, or pulp as they are termed, are dropped into a channel below and thence carried to the continuous presses by a chain and bucket elevator.

"As I have indicated, the line battery differs from the circular only in the arrangement of the diffusers and the carrier necessary to charge them.

"Fig. 9 illustrates a circular battery, Riedel's system, constructed by the Hallesche Maschinenfabrik, Halle a. S.

"THE CONTINUOUS DIFFUSER.

"Since the invention of what is termed the German diffusion process, by Robert, it has been a favorite idea to devise a continuous diffuser. Robert himself attempted this, but without success. About six years ago Mr. Charles invented a continuous diffuser, which was afterwards successfully modified by Mr. Peret, of Roye, France. The following description of the continuous diffuser has been taken from the Bulletin de la Société Industrielle d'Amiens, 1882:

"The continuous diffuser consists of an iron cell, cylindrical in form, resting horizontally upon a foundation of masonry. Within this cell is a perforated iron cylinder, 1.30 meters (4.26 feet) in diameter and 11.20 meters (36.74 feet) in length. The axis is formed by a smaller cylinder. Between these two cylinders is a helix, pitch 70 centimeters (2.3 feet). The inner cylinder is revolved by a suitable connection with a shaft. The speed of revolution is so adjusted that it requires 60 minutes for the beet cuttings to traverse the length of the helix. The cossettes are continually immersed in water. The water enters the cell at the end where the exhausted cossettes are expelled. An automatic arrangement controls the amount of water admitted and keeps it at a certain level. The water gradually becomes charged with sugar and finally leaves the cell at the end where the fresh cossettes enter it.

"The conditions for a good diffusion are fulfilled when the cossettes and water move in opposite directions, the juice becoming more and more concentrated as it passes cossettes richer and richer in sugar.

"The water enters at a temperature of 30° C. (86° F.). It is heated as it passes the coils placed between the fixed cell and the revolving cylinder, and its temperature is gradually increased to 75° C. or 80° C. (167° or 176° F.), and then, as it strikes fresh cossettes, it gradually becomes colder and leaves the diffuser at a temperature of 50° C. to 60° C. (122° to 140° F.).

"Three small vertical test cylinders are placed at equal distances from one another and serve for determining the specific gravity and the temperature of the juice. These observations are made at regular intervals and the results are entered in a note-book.

* * * * * * *

"In the ordinary form of diffusion battery the ten or twelve diffusers demand the constant attention of a skilled workman. He must open and close the various valves from six to seven hundred times in the twelve hours he is on duty.

"The continuous diffuser requires but little attention after one has regulated (1) the speed of the slicer, (2) the speed of the elevator which removes the exhausted cossettes, (3) the speed of rotating cylinder, (4) the pressure of steam on the coils, (5) the exit of the juice which controls the entrance of the water.

"It is only necessary to note the temperature at intervals and regulate the pressure on the coils. The temperature and the quality of the beets are the only variables. One man and a boy are sufficient to conduct the diffuser, beet slicer, and pulp presses.

"The following certificate will explain itself.

"Complete machinery for working 2,000 hectoliters (44,000 gallons) of juice in twenty-four hours, including engines, beet slicer, the diffuser (with elevator for exhausted cossettes), Klusemann pulp presses, and transmission of power, etc.; total cost, 50,000 francs ($10,000); cost of repairs per season, 500 to 700 francs ($100 to $140).

"Labor per ton of beets worked, not including washing the beets, 16 centimes (3.2 cents).

Results obtained.

Mean density of 2,000 hectoliters of juice		*1.036
Beets, per 100 liters, and each degree of density	kilograms	21.00
Masse cuite per 100 kilograms of beets	liters	6.63
Masse cuite per hectoliter of juice	do	1.45
First sugar, white, per 100 kilograms of beets	kilograms	4.492
Sugar per 100 liters of masse cuite	do	68.
Second molasses per 100 kilograms of beets	liters	4.06
Second molasses per 100 liters of first masse cuite	do	61.
Second sugar per hectoliter of masse cuite	do	44.
Molasses per 100 kilograms of masse cuite	do	44.
Beets, per 100 kilograms of masse cuite	kilograms	†1,000.
Pulp per 100 kilograms of beets	do	40.
Sugar per 100 kilograms of pulp	do	0.41

ROUSSEAU,
Chef de fabrication à Frayieres.

The following table shows the results obtained in the sugar house at Roye (Somme), France:

Table showing the extraction—Roye sugar house (France), 1881 and 1882.

Date.	Specific gravity of the beet.	Specific gravity of the juice.	Temperature.	Juice.	Sugar left in the cossettes.
1881.			°C.	*Hectoliters.*	*Per cent.*
September 28		1.023	66	900	
September 29	1.050	1.026	66	1325	
September 30		1.028	66	1495	0.82
Averages	1.050	1.026	66	1217	0.82
October 1	1.053	1.0295	70	1275	0.57
October 2		1.029	69	300	
October 3	1.0515	1.029	69	1500	0.58
October 4	1.0535	1.0339	66	1725	0.55
October 5	1.0541	1.0333	60	1575	0.47
October 6	1.0521	1.030	66	1700	0.45
October 7	1.0555	1.032	63	1725	0.40
October 8	1.053	1.030	66	1575	0.45
October 9	1.0525	1.0355	78	1000	0.44
October 10	1.0525	1.036	75	1825	0.37
October 11	1.0535	1.032	73	1650	0.51
October 12	1.0525	1.033	73	1750	0.45
October 13	1.052	1.034	73	1750	0.42
October 14	1.0545	1.034	73	1750	0.48
October 15	1.054	1.036	73	1725	0.57
October 16	1.054	1.033	73	2000	
October 17	1.0555	1.035	71	1775	0.45
October 18	1.054	1.0345	72	2000	0.44
October 19	1.057	1.035	72	1700	0.55

* Or 3°.6. † 2,200 pounds.

Table showing the extraction, etc.—Continued.

Date.	Specific gravity of the beet.	Specific gravity of the juice.	Temperature.	Juice.	Sugar left in the cossettes.
1881.			°C.	*Hectoliters.*	*Per cent.*
October 20	1.0535	1.032	70	1675	0.50
October 21	1.055	1.033	66	1600	0.57
October 22	1.0548	1.033	69	1200	0.60
October 23	1.055	....	76	300	0.45
October 24	1.0535	1.030	77	1700	0.48
October 25	....	1.030	78	1800	....
October 26	1.055	1.0347	78	1800	0.52
October 27	1.049	1.0349	78	1850	0.40
October 28	1.051	1.035	78	1900	0.38
October 29	1.055	1.0353	77	1975	0.39
October 30	1.055	1.0377	78	2000	0.40
October 31	1.054	1.0378	78	1875	0.41
Averages	1.0549	1.0339	71	1725	0.51
November 1	1.0525	1.0367	78	1950	0.40
November 2	1.054	1.0367	79	1950	0.39
November 3	1.053	1.0364	79	1925	0.39
November 4	1.051	1.0369	79	2025	0.40
November 5	1.054	1.0378	79	1975	0.43
November 6	1.055	1.0366	79	1450	0.44
November 7	1.054	1.0365	79	1875	0.54
November 8	1.0518	1.0365	80	1900	0.44
November 9	1.053	1.0365	80	2000	0.44
November 10	1.053	6.0363	80	1825	0.37
November 11	1.0525	1.0368	80	1625	0.44
November 14	1.052	1.0381	89	1275	0.36
November 15	1.052	1.0372	72	1925	0.40
November 16	1.0565	1.0372	75	2000	0.39
November 17	1.056	1.0366	76	2000	0.39
November 18	1.0555	1.0363	75	1925	0.40
November 19	1.052	1.0358	78	1950	0.44
November 20	....	1.0357	78	1400	....
November 21	1.055	1.0357	72	1775	0.40
November 22	1.055	1.0357	74	2625	0.32
November 23	1.051	1.0351	76	2000	0.34
November 24	1.055	1.035	77	2000	0.36
November 25	1.053	1.0357	78	2000	0.25
November 26	1.053	1.0349	78	2000	0.30
November 28	....	1.0348	78	575	....
November 29	1.0575	1.0348	77	1950	0.50
November 30	1.0525	1.0346	77	2025	0.48
Averages	1.0535	1.0361	77.5	1940	0.40
December 1	1.0525	1.0351	78	2000	0.43
December 2	1.054	1.036	78	2050	0.33
December 3	1.052	1.0365	79	1950	0.36
December 4	1.051	1.0353	83	1900	0.38
December 5	1.0505	1.0352	86	2000	0.37
December 6	1.050	1.0356	84	1975	0.38
December 7	1.051	1.0350	84	2000	0.39
December 8	1.053	1.0358	86	1975	0.35
December 9	1.049	1.0369	86	2000	0.48
December 10	1.0505	1.0357	85	1950	0.39
December 11	1.050	1.0364	85	825	0.36
December 12	1.051	1.0355	82	2000	0.32
December 13	1.050	1.0361	81	2000	0.35
December 14	1.0477	1.0359	80	2000	0.42
December 15	1.0495	1.0363	80	2000	0.37
December 16	1.0495	1.0357	80	2000	0.37
December 17	1.0485	1.0356	86	2000	0.44
December 18	1.050	1.0352	82	1375	0.44
December 19	....	1.0326	85	450	....
December 20	1.0525	1.038	82	2000	0.65
December 21	1.053	1.041	87	2050	0.79
December 22	1.0508	1.0403	87	2050	0.88
December 23	....	1.0392	88	2000	....
December 24	1.0461	1.0380	86	1575	....
December 26	1.054	1.0387	87	1400	0.52
December 27	1.050	1.0383	89	2000	0.51
December 28	1.050	1.041	90	2000	0.52
December 29	1.0448	1.039	90	2000	0.46
December 30	1.0455	1.0395	90	2000	0.45
December 31	1.046	1.0396	91	2050	0.48
Averages	1.050	1.038	84.5	2000	0.44

Table showing the extraction, etc.—Continued.

Date.	Specific gravity of the beet.	Specific gravity of the juice.	Temperature.	Juice.	Sugar left in the cossettes.
1882.			°C.	*Hectoliters.*	*Per cent.*
January 2	....	1.0376	88	1425	....
January 3	....	1.038	89	2000	....
January 4	1.053	1.041	89	1975	0.57
January 5	1.0509	1.0374	88	2000	0.55
January 6	1.0505	1.039	88	2000	0.54
January 7	1.0495	1.0375	88	2000	0.57
January 8	....	1.039	87	1500	....
January 9	1.048	1.0375	88	1575	0.57
January 20	1.052	1.0386	90	1250	0.55
January 21	1.051	1.038	90	1900	0.50
Averages	1.0513	1.038	88.5	1980	0.56

"It may be safely stated that in Germany and Austro-Hungary not less than 90 per cent. of the sugar-houses employ the diffusion process for extracting the juice. The proportion in France is much smaller, owing to the tax being based upon the sugar actually extracted. Since the passage of the new law, levying the tax as in Germany, many French sugar-houses have adopted this process. I believe that in a few years the diffusion will be the only process employed for extraction, except in a few districts where local conditions prevent its adoption.

"EVAPORATION.

"The economical evaporation of the juice is one of the most important problems with which the sugar manufacturer has to deal.

"The hydraulic presses yield 100 pounds of dilute juice per 100 pounds of beets. With the diffusion process this proportion is considerably larger, being 120 pounds dilute juice per 100 pounds of beets. It is evident from the above statements that a beet-sugar house employing the diffusion process must be supplied with evaporating facilities at least one-fifth greater than one employing hydraulic presses. Inventors have not been backward in their efforts to meet this demand for improvements in the apparatus for rapid and economical evaporation.

"One of the most recent and important improvements in multiple-effect apparatus is known as the Welner-Jelinek system.*

* Since the above was written three or four new multiple-effect pans have been invented in this country. Information concerning them may be had by addressing the Kilby Manufacturing Company, Cleveland, Ohio; Thomas Gaunt, 115 Broadway, New York; Geo. M. Newhall Company, Philadelphia; Fort Scott Foundry, Fort Scott. Other makers of evaporating apparatus are John Turl & Sons, No. 534 West Twenty-eighth street, New York; Edwards & Hauptman, 22 Front street, New Orleans; Joseph Oat & Sons, 228 Quarry street, Philadelphia; Whitney Iron Works, New Orleans; John S. Moore, 169 Gravier street, New Orleans; John H. Murphy, 123 Magazine street, New Orleans; H. Dudley Coleman & Co., No. 9 Perdido street, New Orleans; Leeds & Co., New Orleans; Colwell Iron Works, 74 Cortlandt street, New York; The Pusey & Jones Manufacturing Company, Wilmington, Del.; The Squier Manufacturing Company, Buffalo, N. Y.; Robert Deely, Brooklyn, N. Y.

"In this system the pans are arranged horizontally and the heating space is divided into two chambers—an upper and lower. This division into chambers permits the passage of the vapors from the upper to the lower, facilitating the discharge of the water of condensation, and increases the heating surface. These chambers are each subdivided into two others of unequal size. The shape of the pan reduces the danger of loss through particles of the juice becoming entangled with the disengaged vapors. In addition there is also the usual arrangement for diminishing this loss."

"TREATMENT OF THE JUICE.

"Preliminary to describing a few of the more important processes employed in the manufacture of sugar from the beet, it may be well to indicate briefly the usual method for treating beet juices.

"Unfortunately, the simple process employed for clarifying cane juices is not at all successful with the beet. Beet juice contains but slight traces, if any, of glucose or reducing sugar, whereas the cane juice usually carries a notable quantity of this substance.

"In treating beet juices a large excess of lime is added, usually from 2½ to 3 per cent. Carbonic acid gas is then forced through the juice, and the excess of lime is precipitated in the form of a carbonate, and carries down with it mechanically many of the impurities. This operation is terminated when the lime precipitate becomes granular and settles readily. At this point there still remains about a gram and a half of lime (CaO) per liter of juice. After having been passed through filter-presses the juice is treated, boiling hot, with ½ per cent. of lime, and carbonic acid is passed through it, until all the lime is precipitated. This operation is termed the *saturation*, the former the *first carbonatation.* The juice is again filtered through presses. Its further treatment is very similar to that of the cane.

"Experiments have been made by Dr. Wiley* which indicate that a modification of this process could be successfully employed with cane juices. This method would be especially applicable in the manufacture of sugar from† sorghum or in the treatment of very dilute diffusion juices.

"The vacuum pans employed in boiling beet sugar are usually very high in proportion to their diameter, in order to enable the panman to build up large crystals.

"As a rule, in Germany, the first sugars are not washed, and polarize 96 per cent. In France, on the contrary, those houses having facilities for making white sugar usually do so, and turn out an article polarizing 99 per cent.

* Bulletin No. 3, Chemical Division, United States, Department Agriculture, 1884.
† For more recent experiments on a manufacturing scale, see Bulletins, Nos. 6 and 14.

"STOEBNITZ SUGAR-HOUSE.

"This sugar-house is located about 15 miles from Halle. The works were erected by a stock company. The stock is divided into 150 shares of 6,000 marks ($1,500). Each share-holder binds himself to furnish the beets from a certain number of acres of land, for which he receives 22 marks ($5.17) per 1,000 kilograms (2,200 pounds), and, in addition, the pulp from his beets. Other farmers are paid 25 marks ($5.87) per ton of 1,000 kilograms, and receive no pulp; but, if they prefer it, they are paid in the same way as the share-holders. This insures a plentiful supply of beets, and is the plan generally adopted by German sugar-houses.

"The soil of the surrounding country tributary to Stoebnitz is rather a light clay, easily worked, and capable of producing an excellent beet. The sugar-house furnishes the seed to the farmers. Selected samples from the field have polarized as high as 22 per cent. sucrose. Glucose is only present in immature beets, or in those which have sprouted in the silos.

"The Stoebnitz sugar-house is located in the center of a great depression, the neighboring hills sloping gradually to it. It is readily accessible by good country roads radiating in all directions. Its location possesses many advantages, and but one serious disadvantage. This latter is its distance from rail communication.

"The greater part of the machinery has been constructed by the Hallesche Maschinenfabrik. Mr. Roediger, a mechanical engineer connected with this establishment, kindly accompanied me on my visit to Stoebnitz.

"As the acreage tributary to Stoebnitz has increased from time to time, the works have gradually reached their present magnitude through successive enlargements; hence, as one would naturally expect, the arrangement of the buildings and machinery is not such as would give the greatest economy of labor. Old walls, constructed for a smaller sugar-house, have imposed many restrictions upon the manager in the disposition of his machinery. Notwithstanding the disadvantages under which he labored, he has succeeded in building up a model sugar-house.

"The carts and wagons are driven directly into the beet shed and discharge their loads through trap-doors into the receiving-room below. Here a large force, composed mostly of women, throw the beets upon the carrier, which transports them to the washers, two in number. The washed beets are then carried by an elevator to an upper story and dumped into cars, to be weighed by the excise officer. The weighed beets are then sliced and conveyed to the two diffusion batteries. These batteries are ranged in a double line, twelve diffusers in each line. They have an united capacity of 600 tons of 2,200 pounds, in twenty-four hours. The batteries are of the Riedel type, constructed some years since. Between the two lines is a large trough to receive the exhausted cossettes, whence they are conveyed to six continuous pulp-presses, four of the type known as Klusmann and the other two Bergreen.

"The pressed pulps still contain from 75 to 85 per cent. of water, and in this moist condition are 40 per cent. of the weight of the beets worked. This pulp is very valuable as cattle food, and sells for about $1.70 per ton. The relative values of diffusion and the old hydraulic press pulps is still a much debated question in some sugar countries. The juice from the diffusers is conducted to a calorisator, where it is heated to about 90° C. (194° F.) and is then treated with lime.

"By the use of calorisators (Fig. 15) it is claimed that the heat expended in the process of diffusion is not lost, and that subsequent op-

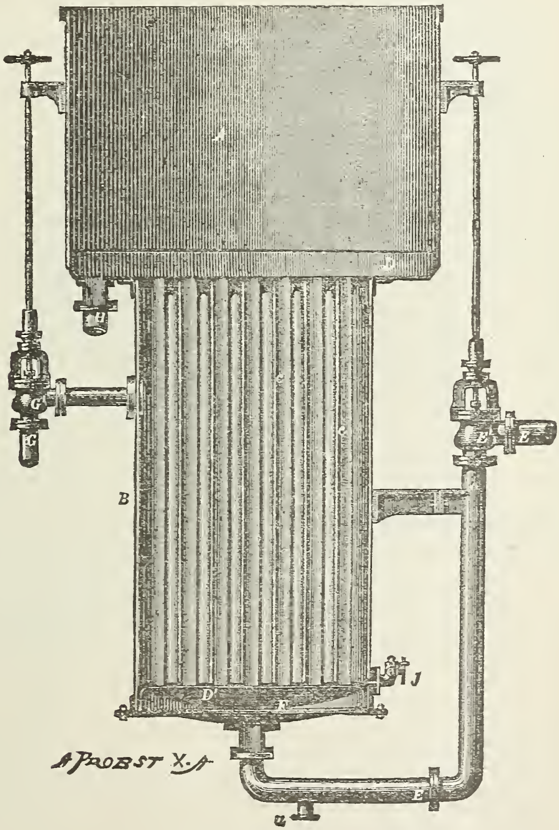


Fig. 48.

erations are carried on much more rapidly than by the old method. Generally in France the juice is conducted into tanks, whence it is drawn off as needed for the carbonatation pans. Consequently it loses much of its heat, and the first carbonatation demands a longer time. This entails a much larger number of carbonatation pans. As at Stoebnitz, also generally in Germany, the carbonatation pans are covered and the foam is kept down by a jet of live steam. In many French sugar-houses, where large open pans are employed, the foam is beaten down by an arrangement of paddles, driven by machinery, and often in addition by a jet of steam.

"The French manufacturer usually commences his first carbonatation at a low temperature, 40° C. (104 F.), which he gradually increases as the carbonatation progresses. By this means he claims that he avoids dangerous combinations between the lime, carbonic acid, and the sugar.

"At Stoebnitz about 2½ per cent. (of the weight of the beets) of lime is employed in the defecation, and the usual quantity, about 1½ grams per liter, is left in the juice after the first treatment with carbonic acid.

"The carbonatated juice, including the suspended precipitate, is sent to the filter-presses. The precipitate is washed with hot water and the washings are added to the filtrate. The filtered juice is treated with a second portion of lime, one-fourth of 1 per cent. of the weight of the beets; the lime is again precipitated by carbonic acid and the juice is passed through the filter-presses; a third portion, about a liter and a half of cream of lime, is then added and afterwards saturated with sulphurous acid. After passing the filter-presses, the juice is concentrated to 23° B.

"This sirup is treated with a final and very small portion of lime, which is precipitated by carbonic acid, and the sirup after filtration is boiled to grain.

"This sugar-house has two double effects, one of the ordinary type, and the second the Welner-Jelinek system.

"The vacuum pans have a capacity, one of 60,000 pounds dry sugar, and the other 25,000 pounds.

"The massecuite is dropped into small coolers, each of about one hectoliter capacity. These coolers are shaped like the frustum of a pyramid, and can be readily transported by means of a small two-wheeled carriage. (See Fig. 49.)

"It requires but little more time to fill these coolers than to drop the masse-cuite into the larger mixers common in Louisiana. The masse-cuite is expelled from the cooler by compressed air. The cooler itself weighs about 50 pounds, and when filled with massecuite, 400 pounds.

"The manager of the Stoebnitz sugar-house stated that he obtains from 4 to 6 per cent. (of the weight of the massecuite) more sugar by allowing it to become perfectly cold before swinging out.

"The next portion of these works that deserves more than this passing notice is the chemical laboratory. It is evident, from the fact that a very large proportion of sugar-houses employ chemists, that the German manufacturers fully appreciate the advantage of a chemical control of the work. Most of the important improvements in processes have had their origin in the laboratory.

"The Stoebnitz works have an excellent laboratory. It is located on the second floor and occupies two large, well lighted and ventilated rooms. The chemist and his assistant keep a chemical control of all the processes. The juice and diffusion pulps are examined at frequent intervals. Samples of the beets from each lot brought to the sugar-house are also analyzed. The laboratory is one of the busiest parts of the sugar-house.

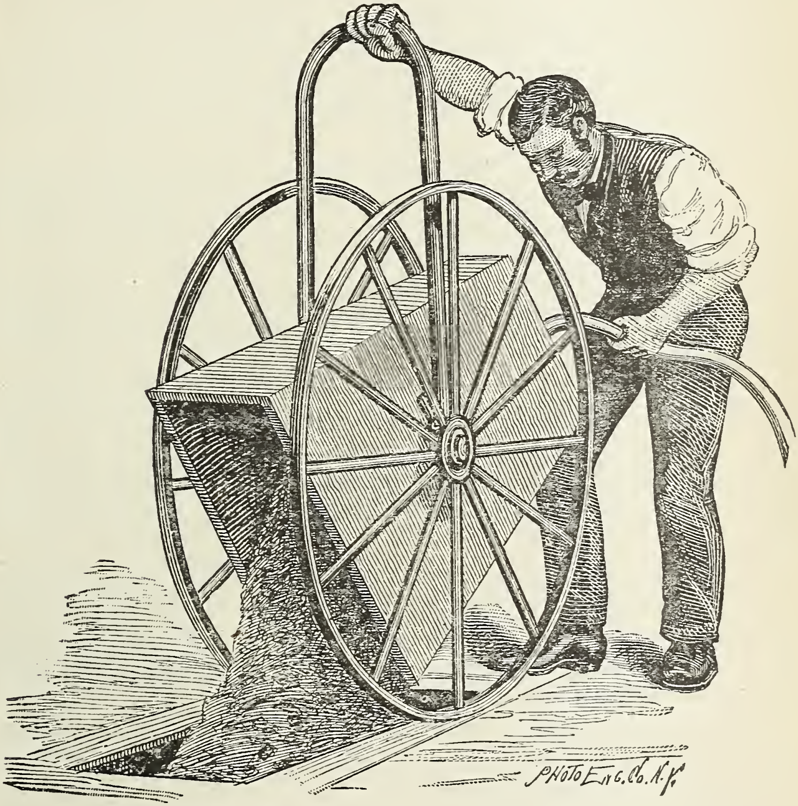


Fig. 49.

" Stoebnitz has unsurpassed advantages for the economical generation of steam. Within 600 yards of the sugar-house there is an inexhaustible mine of lignite or brown coal. This lignite is mined very extensively, and transported upon a tram-way to the works, and is dumped into large bins above the boilers. By an automatic arrangement it is fed directly upon the fires.

" Lignite furnishes an excellent fuel, but yields only about a third as much heat as bituminous coal. The ash amounts to about 14 per cent. The cost of lignite delivered at the machine works in Halle is less than $1 per ton. Good bituminous coal costs in the same locality from $3.75 to $4.50 per ton.

"CAMBURG SUGAR-HOUSE.

"The sugar factory at Camburg is situated on the river Saale, about 25 miles from Halle. The buildings are located about 100 yards from the river, from which the works derive an unfailing supply of water.

"Comparatively few beet-sugar houses have equal water advantages. In most factories the vapors from the evaporating juices are condensed and the water is used again and again. This necessitates a special arrangement for cooling the water. This consists of a frame-work, supporting bundles of willow twigs, over which the water passes, falling from one bundle to another, until it finally reaches the reservoir which supplies the factory.

"A branch railway has been constructed, connecting with the main line, and beets are brought in and dumped directly into the carriers. These latter consist of a system of narrow cement-lined trenches, through which a constant stream of water is flowing.

"The rapidly-flowing current propels the beets, and finally drops them into a box, from which they are carried by an elevator to the washers, two in number.

"This hydraulic carrier, as it is termed, is a very convenient and eco nomical method for transporting beets, and for factories having a good water supply can be highly recommended. The trenches are easily constructed, and are so arranged that they admit of ready access for repairs. The water of condensation furnishes the supply for the conduits.

"The washed beets fall upon a perforated plate, which is rapidly shaken by machinery in order to throw off the water and dry them as much as practicable. This is evidently very important, as an excise tax is levied on the washed beets. The water so thrown off amounts to at least 2 per cent. of the weight of the beets.

"The diffusion battery is of the Hallesche Machinenfabrik construction, and has all the latest improvements.

The diffusers are arranged in a circle and discharge the pulp into a central basin, whence it is lifted to the presses by a chain and bucket elevator. The helix form of elevator for pulp is no longer used with Riedel's battery, as it will not work satisfactorily at so great an angle as 45°.

"The presses are of the Bergreen type. It will be noticed that two presses only are required to do the same work as three at Stoebnitz. The process employed at Camburg for extracting the sugar from th juice does not differ materially from that in vogue in most of the sugar-houses in France. The only difference is in the reheating of the juice coming from the diffusers, before carbonatation; this is accomplished by two calorisators, in one of which the temperature is raised to a certain degree by exhaust-steam and in the other to 90°C. by direct steam. I would again call attention to this idea of conducting the first carbonatation at a high temperature.

"Not having been able to secure analyses of the juice, I can not say whether the results are better than by the old process or not. This method certainly has the advantage of hurrying the precipitation, and by diminishing the time required, a few pans will do the work of several working in the old way, and there is still another advantage. Since the precipitation is accomplished so much more rapidly, it is evident that the carbonic acid is better utilized and that the waste is reduced to a minimum.

"A series of montes jus are employed to force the juice to any part of the sugar-house. Instead of steam pressure, compressed air is employed. As soon as a monte jus is emptied, the air-pump is connected with it and the air is forced into another. By this method the power expended in compressing the air is economized. The use of compressed air instead of high-pressure steam is not only much more economical, but in addition possesses the advantage of not injuring the juice.

"The quantities of lime (CaO) employed are as follows: 1st. Carbonatation 2.25 to 2.5 per cent. of the weight of the beets. Saturation, .25 per cent. 1.0 to 1.5 grams lime per liter of juice is left after the first carbonatation; after the saturation .03 to .04 gram.

"The lime is placed in wire baskets, which are lowered into the carbonatation pans. This plan is considered preferable to adding slacked lime.

"The lime precipitate, usually termed scum or mud, is washed in the filter-press by a stream of water. This precipitate amounts to about 6 per cent. of the weight of the beets worked.

"While on this subject it may be well to speak of two of the more important processes for the recovery of the sugar left in the scums.

"The proper treatment of the scums is of very great importance. Unwashed scums contain about 4 per cent. sugar, and amount to at least 9 or 10 pounds per hundred pounds of beets. This corresponds to a loss of .36 to .40 per cent. sugar, or 7.9 to 8.8 pounds of sugar per long ton of beets.

"By means of an ingenious device for washing, Mr. Charles Gallois has succeeded in reducing the loss of sugar to from .20 to .40 per cent. of the scums.

"This device consists of a three-way valve, so arranged that the filter-press can be placed in communication with either the monte jus containing the scums, a mixture of scum and hot water, or boiling water. This simple device can be attached to any filter-press.

"To operate the press: Open wide the valve connecting with the scums. The press soon fills. When the volume of juice flowing from the press diminishes perceptibly, change the valve and admit scums diluted with water. The density of the juice will now rapidly diminish. Open the water valve and pass boiling water through the press until the density indicates that but little juice is being extracted. The last portions of dilute juice are employed to slack lime for the defecation.

"Another successful method is as follows: The scums are pressed in an ordinary filter; the residue, or precipitate, is removed from the filter, thoroughly mixed with water, and is again pressed. This results in a very decided decrease in the weight of the scums, showing that a large proportion of the sugar has been extracted. It is claimed that this method reduces the danger of redissolving the impurities contained in the lime precipitate.

" When this factory was constructed two years since the process for treating the juice with sulphurous acid and entirely suppressing the use of bone-black was not yet an assured success, consequently, rather than risk a new and still uncertain process, the new works were supplied with a battery of closed filters and a Langen-Schatten bone-coal kiln. Since this time the sulphurous acid process has advanced very much in favor with sugar manufacturers, and now many sugar-houses entirely suppress the use of bone-black.

" For evaporation this house has one triple-effect, and for boiling to grain, one vacuum pan. The barometric vaccum pump is used.

"TREATMENT OF THE MASSECUITE.

"The massecuite is dropped into small coolers, similar to those at Stoebnitz (Fig. 16). 2 feet 6 inches deep, 10 inches long, 1 foot 6 inches wide at top, and 1 foot at the bottom. Capacity approximately 1.4 hectoliters.

"After remaining 12 hours in the cooling room the massecuite is expelled from the cooler by compressed air, and is dropped into the mixer below. It is claimed that by the use of these coolers the yield of first sugar is largely increased.

" Dr. Prella, superintendent of the Camburg works, made an experiment two or three years since, to determine if this is really the case. He took equal volumes of the massecuite, then swung out the sugar from one immediately after dropping it from the pan; the yield was 62 per cent. sugar. The second portion he set aside 12 hours, until it was perfectly cold; this yielded 68 per cent. sugar, a gain of 6 per cent. He now invariably allows the massecuite to become cold before swinging out. The following are a few percentages taken from Dr. Prella's notebook and show the amount of sugar obtained several days in succession last season: 75 per cent., 74 per cent., 74.2 per cent., 77 per cent., 71 per cent., 72 per cent., 76 per cent.

" The Camburg sugar-house has not yet finished its second campaign. Its first year's work was remarkably successful. The house being supplied with every facility for good work, and having an exceptionally good harvest of beets, both as regards quantity and quality, yielded a very large profit to the owners. The cost of the sugar-house was about $225,000. Its capacity is 300 long tons per 24 hours, or 30,000 tons for the campaign. This establishment at Camburg is in every respect a model sugar-house.

"DETAILED STATEMENTS OF THE WORKINGS OF SEVENTEEN GERMAN SUGAR-HOUSES.

"In order to determine a basis for taxing the beet-sugar industry, the German Government selects certain sugar-houses and requires them to make detailed reports. In these reports each sugar-house is designated by a letter of the alphabet. Care is taken to select only those factories which are fair representatives of the districts in which they are located.

"The copy of these tables for 1882 and 1883, which accompanies this report, is given to show as briefly as possible statistics of the yield and expenses in the manufacture of beet sugar.

Campaign of 1882 *and* 1883.

Designation of sugar-house	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.	N.	O.	P.	Q.	R.
Polarization calculated on weight of beet	10.72	11.44	11.86	10.83	10.85	10.90	10.50	10.90	10.05	11.20	10.47	9.66	10.44	10.53	10.09	11.47	10.90
Non-sugar calculated on weight of beet	2.65	2.62	2.77	2.66	2.95	2.82	2.60	2.68	2.87	2.54	2.59	2.94	2.45	2.86	2.89	3.93	2.50
Co-efficient of purity	80.21	81.36	81.07	80.28	78.62	79.46	80.15	80.24	77.80	81.50	80.14	76.66	80.99	78.64	77.73	74.40	81.37
Available sugar	8.70	9.31	9.60	8.69	8.53	8.76	8.42	8.77	7.82	9.13	8.39	7.40	8.44	8.28	7.84	8.53	8.86
Masse-cuite	12.19	12.27	12.06	11.53	11.92	11.89	11.11	10.84	13.73	11.99	11.36	11.38	13.32	10.63	10.86	11.65	11.36
Polarization of masse-cuite	84.90	87.60	84.34	85.73	84.40	85.37	85.60	86.94	84.70	85.58	84.43	83.04	85.48	84.10	85.27	83.90	84.46
Sugar obtained from the masse-cuite	83.76	80.25	77.89	76.54	75.29	76.87	76.69	80.67	73.42	75.70	73.77	76.97	75.25	82.68	72.83	76.53	81.82
Sirup obtained from the masse-cuite	7.92	20.29	21.68	23.42	24.61	21.16	25.74	12.88	14.22	23.92	26.23	19.68	10.85	17.15	30.08	23.52	9.98
Sugar obtained	10.21	9.85	9.40	8.82	8.97	9.14	8.51	8.75	10.05	9.07	8.38	8.77	10.02	8.77	7.90	8.94	9.30
Sirup obtained	0.97	2.50	2.61	2.70	2.93	2.51	2.86	1.39	2.14	2.87	2.78	2.24	1.45	1.82	3.26	2.74	1.13
Polarization of the first products	95.89	95.67	95.40	95.70	95.60	96.03	95.60	96.66	94.14	95.63	96.40	94.42	94.98	95.35	96.90	94.22	95.14
Valuation of the sugar in dollars per 100 lbs. (German = 110 lbs.)	$6.80	$6.87	$6.73	$6.80	$6.93	$6.98	$7.00	$6.95	$6.75	$6.76	$7.03	$6.56	$6.65	$6.86	$7.49	$6.55	$6.84
Cost of sugar in dollars per 100 lbs. (German = 110 lbs.)	$5.52	$5.73	$5.65	$5.86	$6.02	$6.09	$6.10	$6.13	$6.17	$6.17	$6.45	$6.02	$6.22	$6.50	$7.12	$6.35	$6.89
Beets worked per hectoliter of brown coal ... lbs.	196.9	233.2	178.2	277.2	198.0	242.0	407.0	372.9	209.0	200.2	195.8	172.7	213.4	320.1	200.2	234.3	232.1
Receipts per ton (2,200 lbs.) of beet roots	$14.16	$14.14	$12.92	$12.75	$13.18	$13.30	$12.64	$12.40	$13.06	$12.96	$12.62	$12.10	$13.52	$12.36	$12.70	$12.13	$12.98
Expenses, not including mortgages, etc	11.56	11.92	10.88	11.08	11.52	11.68	11.10	10.96	12.10	11.88	11.64	11.04	12.68	11.72	12.12	11.98	13.06
Gross profit per ton (2,200 lbs.) beets	2.60	2.22	2.04	1.64	1.64	1.60	1.52	1.42	1.14	1.06	0.98	0.94	0.82	0.62	0.58	0.34	....
Gross loss per 100 lbs. of beets	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

A.—EXPENSES FOR BEETS AND TAXES PER TON (2,200 LBS.) OF BEETS.

	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.	N.	O.	P.	Q.	R.
Beets	$4.94	$5.58	$5.02	$5.08	$5.58	$5.32	$4.86	$5.08	$5.48	$4.94	$5.42	$4.84	$5.48	$6.10	$5.36	$5.32	$6.42
Taxes	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76
Totals	8.70	9.34	8.78	8.84	9.34	9.08	8.62	8.84	9.24	8.70	9.18	8.60	9.24	9.86	9.12	9.08	10.18

B.—MANUFACTURING EXPENSES PER TON (2,200 LBS.) OF BEETS.

Designation of sugar-house	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.	N.	O.	P.	Q.	R.
Fuel	$0.90	$0.80	$0.80	$0.62	$0.67	$0.82	$0.68	$0.63	$0.86	$0.86	$0.87	$0.80	$1.00	$0.61	$1.05	$0.76	$0.81
Light	.04	.02	.04	.02	.07	.02	.01	.01	.03	.02	.03	.03	.04	.02	.03	.04	.07
Freight	.04	.04	.04	.04		.12	.09	.07		.16	.03	.04	.05		.09	.01	
Sacking sugar	.02	.04	.02	.06		.02	.03	.02	.06	.04	.03	.02	.03	.02	.05	.01	.07
Buildings and repairs	.06	.06	.08	.04	.03	.01	.02	.05	.02	.03	.01	.02	.03	.02	.14	.06	.05
Bone-coal	.10	.12	.12	.06	.09	.11	.09	.08	.11	.10	.05	.07	.09	.08	.07	.12	.05
Wages	.62	.62	.40	.44	.65	.43	.44	.37	.61	.69	.59	.58	.62	.38	.45	.63	.66
Machinery and repairs	.20	.22	.28	.24	.13	.17	.18	.22	.17	.18	.13	.19	.37	.18	.21	.29	.12
Provisions	.10	.08	.06	.08		.07	.06	.07	.07	.07	.07	.06	.11	.06	.09	.07	.06
Oil for vacuum pans	.02	.02	.02	.02	.01			.01	.01	.01	.01	.01	.05	.01	.01	.03	.01
Machines, oil, and grease	.02	.02	.02	.02	.02	.01	.01		.02	.02	.02	.02	.01	.01	.01	.01	.01
Muriatic acid	.02	.02	.02	.02	.02	.01	.04	.03	.02	.03	.01	.02	.01	.02	.01	.06	.04
Minor apparatus	.02	.02	.02			.01		.02	.02	.03		.01		.01	.04	.05	.01
Lime	.06	.04	.04	.08	.10	.10	.06	.05	.11	.07	.01	.04	.24	.07	.06		.05
Canvas and linen	.06	.04	.02	.06	.05	.04	.05	.02	.02	.05	.04	.03	.18	.04	.02	.06	.04
Wood, coal, and coke	.04	.04	.02	.02	.03	.02	.01	.05	.05	.05	.05	.05	.11	.04	.08	.03	.03
Spirits, osmose paper	.02			.02		.01			.04	.01		.01					.02
Totals	2.34	2.20	2.00	1.84	1.87	1.97	1.77	1.70	2.22	2.42	1.95	2.00	2.94	1.57	2.41	2.23	2.10

C.—OTHER EXPENSES PER TON (2,200 LBS.) OF BEETS.

Designation of sugar-house	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.	N.	O.	P.	Q.	R.
Insurance	$0.04	$0.04	$0.03	$0.05	$0.04	$0.04	$0.02	$0.03	$0.06	$0.04	$0.05	$0.03	$0.06	$0.03	$0.06	$0.04	$0.07
Interest and discount	.23	.20		.22	.10	.36	.51	.23	.33	.44	.28	.36	.31	.17	.31	.39	.49
Salary	.14	.16	.08	.09	.12	.08	.08	.11	.11	.14	.10	.10	.09	.08	.16	.12	.14
Various expenses	.10	.08	.04	.11	.07	.08	.08	.05	.14	.14	.09	.06	.05	.07	.09	.12	.09
Totals	.51	.48	.15	.47	.33	.56	.69	.42	.64	.76	.52	.55	.51	.35	.62	.67	.79

"THE EXTRACTION OF THE SUGAR FROM THE MOLASSES.

"It has long been a problem with sugar manufacturers to devise a method for extracting the sugar from the molasses. The importance of this problem is such that it has led many of the most noted inventors in the field of sugar manufacture to investigate it. It is stated that in France 15 per cent. of the sugar in the beet remains in the molasses. This corresponds to a loss of about 1½ per cent. on the weight of the beet. This loss is even more important in the beet than the cane sugar manufacture. The beet molasses is very highly colored and has an extremely disagreeable taste. In fact, it can only be utilized for the manufacture of vinegar or for distilling purposes.

"Quite a number of processes have been proposed for the extraction of the sugar from molasses, a few of which have been successful. From a chemical point of view this is a comparatively easy problem, but commercially or mechanically speaking it is an extremely difficult one.

"It is a well-known fact among manufacturers that all the sugar can be readily separated by precipitation as a barium saccharate, but the cost of the barium salt precludes its use. Again, the processes known as "elution," depending upon the precipitation of a lime saccharate and subsequent washing of this precipitate with dilute alcohol, are both chemically and mechanically successful. The elution processes, however, can only be employed in those countries where alcohol either pays a very low excise tax, or is entirely free from tax when used for manufacturing purposes. These brief statements merely indicate the difficulties which the chemist and manufacturer have been compelled to face. In many instances, after a long series of experiments in his laboratory, the chemist has been compelled to yield to difficulties not always chemical, but often of a purely mechanical nature.

"For example, he has succeeded in producing a saccharate of lime, containing all the sugar in the molasses; but the saccharate would contain many impurities which could only be eliminated by careful washing. On attempting to wash this combination between the lime and sugar the filter-press would soon clog and refuse to do the work. Had the precipitated saccharate been granular this would not have been the result. Notwithstanding these difficulties and failures two successful processes have been devised. In the more recent, the Steffen separation process, the inventor has succeeded in readily producing a granular precipitate of tribasic saccharate of lime. The other process is termed the Strontium Process. Not having had an opportunity to visit works employing strontium, I shall only describe the Steffen process.

"CHEMISTRY OF THE SEPARATION PROCESS.

"Very complete investigations have been made of the lime saccharates, with the especial object of utilizing their properties in the separation of sugar. The lime saccharates are three in number:

Monobasic $(C_{12}H_{22}O_{11})$, CaO.
Dibasic $(C_{12}H_{22}O_{11})$, 2 CaO.
Tribasic $(C_{12}H_{22}O_{11})$, 3 CaO.

"Some chemists claim the existence of a fourth, the tetrabasic.

"If a portion of finely powdered pure quicklime be added to a 6 to 12 per cent. sugar solution, in the proportion of one molecule of lime for each molecule of sugar, the temperature of the solution being kept below 30° C. (86° F.), the monobasic saccharate of lime will be formed. This saccharate is perfectly soluble in water. It is necessary for the success of this experiment that the quicklime be recently calcined and finely powdered.

"If this solution of monobasic saccharate be heated it will be decomposed and the tribasic saccharate precipitated. To form the dibasic saccharate it is necessary to add an additional molecule of lime, under the same physical conditions as before. The dibasic saccharate may be separated by crystallization in the cold.

"The tribasic saccharate is much more important from a commercial point of view than the others. It is with difficulty soluble in 200 parts of water, but insoluble in a saturated water solution of the tribasic salt itself. When precipitated under certain well-defined conditions it is granular. Sugar can be completely precipitated in this combination from a dilute solution. This precipitate being crystalline can readily be washed in a filter.

"To form the tribasic saccharate proceed as follows: Dissolve a certain quantity of sugar in water, making a 6 to 12 per cent. solution. By means of some suitable arrangement keep this solution at a temperature below 30° C (86° F.). For every molecule of sugar add three molecules of very finely-powdered and freshly-burned lime. The lime must be added in small portions, the solution being stirred constantly. The tribasic saccharate of lime will be precipitated.

"The following analyses show the composition of the saccharate obtained by the above method:

	By analysis.*	Calculation.
Carbon (C)	25.30	25.53
Hydrogen (H)	5.14	4.96
Oxygen (O)	38.12	48.23
Calcium (Ca)	21.44	21.28

* De la Diffusion. Par Jules Cartuyvels, p. 263.

"This saccharate is readily soluble in a sugar solution.

"The tribasic saccharate of lime can not be preserved any great length of time. Even at the end of two or three weeks the proportion of sugar decreases. The sugar decomposes and forms organic salts with the lime.

*"The crystals of sugar obtained by the separation process resemble a confused mass of needles. If these crystals be dissolved in water and recrystallized they will assume the normal form.

* The peculiar form of these crystals is due to the presence of rafinose.

"THE SEPARATION PROCESS.

"I visited the sugar-house at Elsdorf, near Cologne, Germany, to examine into the practical workings of this process. The Elsdorf sugar-house was the first, I believe, to adopt it, and experiment upon a large scale. I afterwards visited the works of Mr. Max Le Docte, at Gembloux, Belgium, and examined the machinery, as adopted by Mr. Steffen after a year's experience in the practical application of his separation process. Plates Nos. 3, 4, 5, and 6 are from drawings kindly furnished me by Mr. Gèrard Oyens, of Paris.

"Before describing the separation process it may be well to speak of the

"COMPOSITION OF BEET MOLASSES.

"The averages of a large number of analyses of beet molasses show its composition to be about as follows:

	Per cent.
Sucrose	47.5
Reducing sugars	.5
Ash	9.3
Water	20.5
Organic matters	22.2
	100.0

"The percentage of reducing sugars as given above is rather high, as beet molasses does not usually contain more than a trace.

"The ash consists principally of salts of potassium, sodium, and magnesium. Phosphate of potassium is one of the principal constituents.

"The recovery of these mineral substances forms quite an industry in connection with the distillation of the molasses. One hundred pounds of molasses yields 10 pounds of black ash.

"The Steffen separation process depends upon the precipitation in the cold of the tribasic lime saccharate, sparingly soluble and of a granular structure.

"The freshly burned quicklime is first broken into small pieces by an ore-crusher, such as is used in the mining regions of this country. The broken lime is carried by an elevator to a mill, where it is ground to a very fine powder. This mill resembles in every respect an ordinary flouring mill. Special precautions are taken to prevent the lime powder from being inhaled by the workmen.

"The powdered lime is next conveyed by an elevator to another room, where it is passed through a fine wire gauze sieve. It is extremely important in this process that the lime be reduced as nearly as possible to an impalpable powder. Precautions are taken to remove any particles of iron from the powder by means of magnets. The powdered lime falls into a box holding a certain quantity, and is divided automatically into equal portions. From this box the portions are dropped at intervals into the mixer containing the diluted molasses. It is necessary that the temperature in this mixer should not rise above 30° C. (86 F.).

The lower the temperature the quicker the lime will combine with the sugar.

"The mixer consists of a large closed iron cylinder placed in a vertical position. Within this cylinder is a system of tubes arranged similarly to those in a pan of an ordinary double effect. Cold water (below 15° C., 59° F.) circulates about these tubes, entering below and discharging from above. The dilute molasses circulates through and above this system of tubes; a helix, revolved by suitable machinery, keeps the mixture in constant motion that it may be quickly cooled.

"The operations for the production of the tribasic lime saccharate are conducted as follows:

"A certain quantity of molasses is accurately measured. Water is added to it until the density of the solution is 12° Brix (6.6° B.), the percentage of sugar being from 7 to 8. This solution is cooled down to 15° C (59° F.); small portions of the powdered lime are then added at intervals of about a minute. The temperature increases a little after each addition of lime. Before adding more lime it must be again reduced to 15° C. This operation continues until lime has been added from ten to thirteen times, when the sugar is all precipitated. The workman determines this point by the density of a "proof" filtered from the mixture. The density of this filtrate should not be greater than 6° to 6½° Brix (3.5° B.). The total quantity of lime added is 93.4 pounds lime per 100 pounds of sugar in the molasses. When this process was first invented much larger quantities of lime were employed, often as much as 150 pounds per 100 pounds of sugar. The chemist at Elsdorf informed me that 93.4 pounds is sufficient.

"The unwashed lime saccharate resembles a dirty milk of lime. After leaving the mixer it is pumped to the filter-presses. The filters are fitted for washing the saccharate in the press. The mother liquor, containing all the impurities of the molasses, is used as a fertilizer. The water for washing the saccharate is carefully measured, and the same quantity per press is always employed. The wash water is afterwards used to dilute the molasses. By this means losses due to the slight solubility of the saccharate are avoided.

"It is important that the pressure on the filter-presses should not exceed two and one-half atmospheres. An excess of pressure over this limit will cause the saccharate to cake in the presses and it will be impossible to wash it.

"The filter-cloths require washing every four or five days. The cloths from one press per day are replaced by clean ones.

"The co-efficient of purity of the saccharate, *i. e.*, the percentage of pure saccharate in the crude, ranges from 97.5 to 98.5, and will avearge about 98.

"If one wishes to simply extract the sugar from the molasses, having obtained the tribasic saccharate, it is only necessary to decompose it with hot water, remove the lime by precipitation and filtration, and evaporate the filtrate. But the greater number of establishments employing the Steffen substitution process work it in connection with beet-sugar houses. In this case the saccharate of lime replaces the lime for defecation.

"It is not sufficient to simply treat the saccharate with water to form a lime paste suitable for defecating. The objection is that the saccharate is in a granular state and is not readily acted upon by the carbonic acid. To produce a perfectly smooth milk of lime, free from grains, the saccharate is decomposed by hot juice. An average of 92 per cent. of the sugar contained in the molasses is extracted by this process.

"EXPENSES FOR LABOR.

"The extreme simplicity of this process is quite noticeable. There are no operations requiring skilled labor aside from the control exercised by the chemist. There is not an operation that can not be performed by a common laborer.

"At Elsdorf the workmen at the mixers receive one mark and a half per day (about 36 cents); at the filter-presses, one and a quarter marks (30 cents). These wages are about the average for the entire sugar-house.

"TREATMENT OF CANE MOLASSES BY STEFFEN'S PROCESS.

"Shortly after the announcement of the successful working of the separation process on a large scale certain London refineries employed a chemical expert to examine the process and report to them. As a successful application of this process would be of great importance to our cane planters, I obtained a copy of this report, and shall give those portions not already included in my description.

"After speaking of the complete success of the Steffen process in the treatment of beet molasses, Mr. Gill, the expert mentioned above, says:

"'How far the same thing can be said in regard to its application to the molasses obtained in the manufacture or refining of sugar from the cane depends on a variety of considerations, of which the following are some of the most important:

"'First. Is the sugar separated as pure as that obtained from the beet molasses, and is any of the glucose (altered and uncrystallizable sugar), which is always present in large quantities, precipitated along with the true cane sugar, and then again set free when the lime compound is decomposed by the carbonic acid, and if so how far the fact will interfere with the economy and utility of the process?

"'The answers to these questions are not clear in the present state of the evidence. I am informed by Mr. Langen and his chemist that some glucose is precipitated, but that they do not know in how large a proportion. This would therefore have to be determined by experiment. I may say with certainty that if all or most of the glucose be precipitated with the sugar, and then again set free along with the sugar by the subsequent treatment with carbonic acid, that very little or no useful effect will be obtained, because glucose when present in solution with sugar greatly hinders, if it does not altogether prevent, the crystallization of an equal weight of the latter on evaporation.

"'That the evil indicated may attain large dimensions is shown by the fact that second sirups obtained in the manufacture of Mauritius sugar contain, according to Dr. Icery, from 22 to 43 per cent. of glucose out of 100 total sugars.

"'Second. Will the mother liquid drain away completely through the cloth of the filter-presses from the precipitated sugar lime when molasses obtained from cane juice in the usual rough manner is the original material operated upon?

"'Here again direct experience is practically wanting. In one experiment which I witnessed, and which was performed on a cane molasses of unknown origin, but believed to be from a refinery, the filtration proceeded without any difficulty. I should remark that solutions of ordinary raw cane sugar can not be filtered through a filter-press, since the gummy matters choke the pores of the cloth, and almost immediately.

"'If the above two points can be settled in a favorable manner then the process will be as great a success in a chemical and mechanical sense as it is with beet molasses.'

"Mr. Gill then discusses the commercial conditions requisite for success. But as these conditions are so different in this country from those in London I shall not repeat them. In conclusion he says:

"'I can not advise your clients to incur the expense of adopting this process until they have satisfied themselves by experiment that it is as applicable to the molasses of cane sugar as that of the beet.

"'I may add that sufficiently extended experiments could be made on a laboratory scale at an expense which would not exceed, say, £40, and which might be less.

"'C. HAUGHTON GILL.

"'To Messrs. MATHESON & GRANT,
32 *Walbrook, London, E. C.*'

*"Not having made any laboratory experiments on the treatment of cane molasses by Steffen's process, I can not add anything to the above report.

"*Estimate for the establishment of works for the treatment of* 10,000 *to* 15,000 *kilograms* (22,000 *to* 33,000 *pounds*) *of molasses per day.*

1 reservoir for molasses, 318 cubic feet capacity, fitted with valves	$182.50
1 reservoir for water, 212 cubic feet capacity	132.50
1 measuring tank, with valve	112.50
1 scale, for weighing molasses	37.50
2 mixers, with connections, at $1,500	3,000.00
2 automatic measuring apparatus for lime, at $162.50	325.00
1 horizontal steam-pump, for the lime saccharate. Cylinder, 12.8 inches diameter; pump, 7.9 inches diameter; stroke, 15.8 inches	1,250.00
1 safety-valve	$37.50
1 gauge	10.00
6 filter-presses, at $675	4,050.00
6 iron funnels, at $43.75	262.50
1 double trough, 34.5 feet long	105.00
1 reservoir; capacity, 88.3 cubic feet (for wash water)	87.50
1 archimedean screw, 37.4 feet long	440.00
1 saccharate mill	750.00
1 pump; 2 plungers, 5.9 inches diameter, stroke 7.9 inches, including transmission of power	475.00
1 saccharate pump; 2 plungers, 3.9 inches diameter, stroke, 7.9 inches	375.00
1 engine; cylinder, 13.8 inches diameter, stroke, 27.6 inches	1,125.00

* Since this was written experiments have been successfully made in treating molasses with lime for the decomposition of the glucoses preparatory to the use of a saccharate process for the separation of the cane sugar.

1 transmission of power (approximate)	$725.00
1 ore-crusher, for lime	537.50
1 mill, to grind the lime	1,212.50
2 elevators (iron), at $300	600.00
1 rotary sieve	660.00
1 hopper, for powdered lime	225.00
1 aspirator	437.50
Total	17,155.00

"The value of the franc in the above estimates is taken at 20 cents.

"In addition to the cost of the machinery a royalty must be paid, depending upon the size of the plant and the length of the working season.

"If the Steffen process is worked in connection with a sugar-house, the royalty is $7,500 for works having a capacity to treat 22,000 pounds of molasses per day, or $10,000 if 33,000 pounds are treated. To these sums $2,500 and $3,750, respectively, must be added, if the Steffen process is to be employed after the regular campaign of the sugar-house is finished.

"If the plant is to be employed the entire year, only for the extraction of the sugar from molasses obtained by purchase, the royalty is $10,000 for a daily capacity of 22,000 pounds; $13,750 for a daily capacity of 33,000 pounds. For larger plants, the royalty is fixed by special contract.

"This process has already been adopted by a number of German sugar-houses, and by eleven this season in Belgium. When I left France in October, the great central sugar-house at Cambrai was about to contract for the installation of the Steffen separation process.

"Plates Nos. 3, 4, 5, and 6 show the disposition of the machinery for working the Steffen process in connection with an ordinary sugar factory.

"NOTE.—Mr. François Sachs, chemist of the Max le Docte Sugar-house, Gembloux, Belgium, has kindly given me the results of his experiments last season with the Steffen process. He says:

"The separation process for the extraction of the sugar from the molasses yields less sugar in actual practice when molasses alone is treated than was expected. In fact, it is necessary to add sugar in order to obtain a good crystallization.

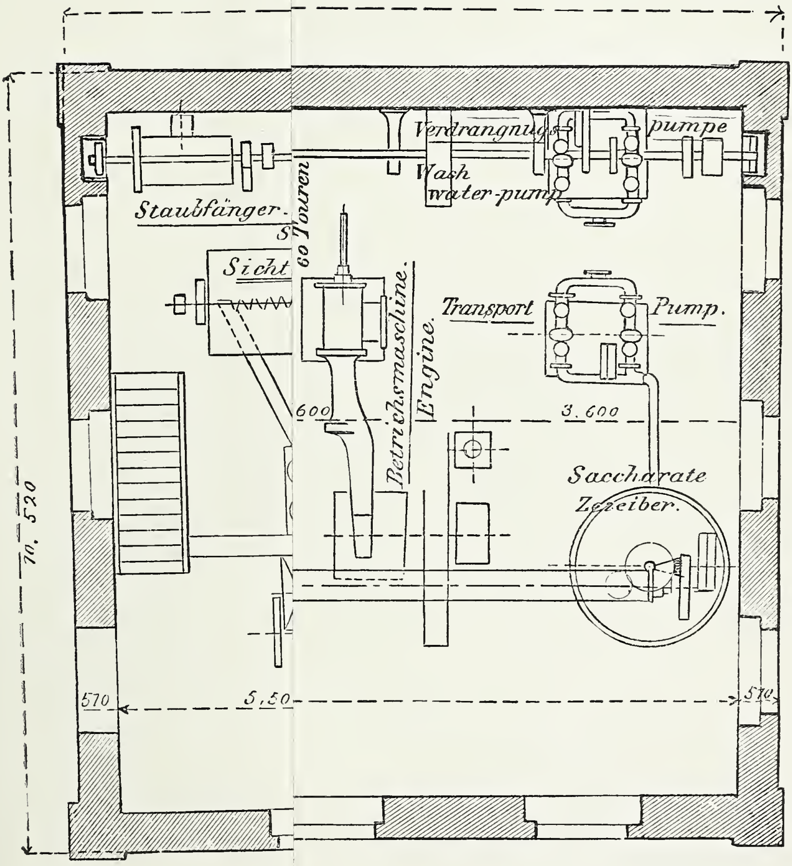
"Taking 100 kilograms of molasses containing 50 per cent. sugar, we have added 24 kilograms of raw sugar (polarizing 89 to 90 degrees) with the following losses based on the weight of the molasses:

	Per cent.
(1) In the mother liquor * (reheated)	1.50
(2) In the filter press deposits	3.27
(3) In the scums from the carbonatation	0.64
Total	5.34

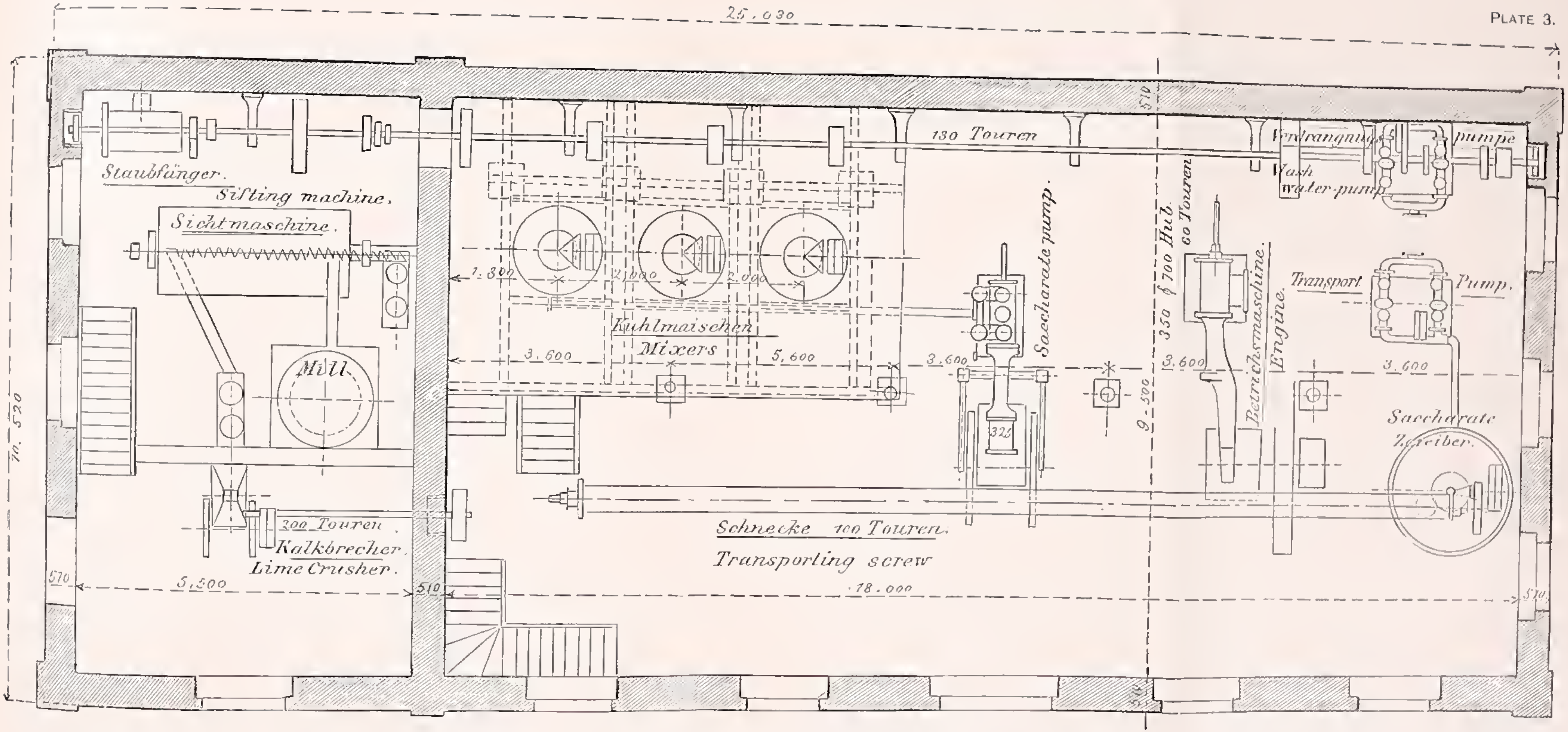
"Then 50 kilograms of sugar in the molasses, minus 5.34 loss, leaves 44.66 kilograms in the masse-cuite. The masse-cuite gave 52.52 per cent. first sugar, or 23.45 per cent. of second molasses. There then remained 24.12 per cent. of second molasses

* The mother liquor dissolves a small portion of the saccharate, which is reprecipitated on heating the liquor, and is mostly recovered in the filter presses.

PLATE 3.



Face page 250.

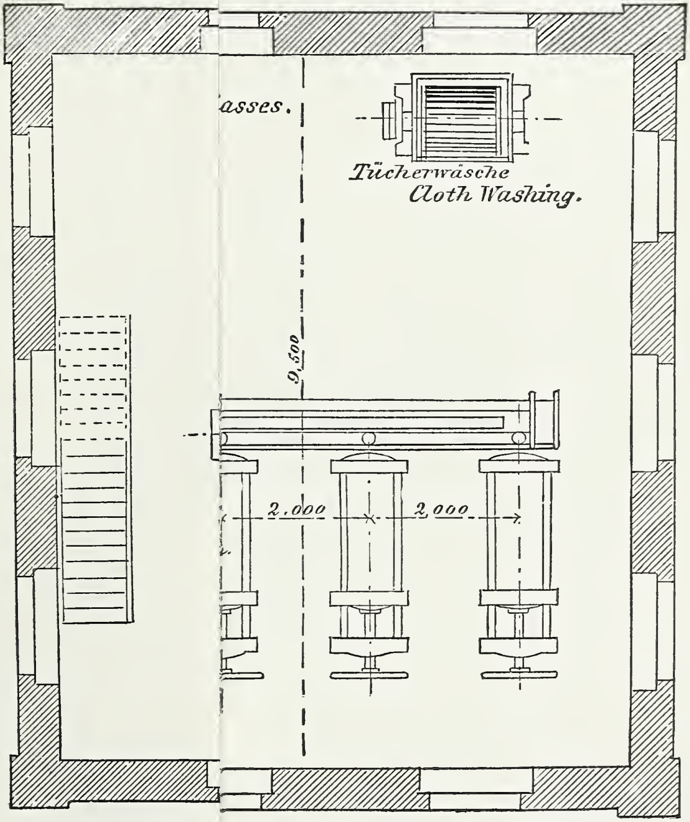


Face page 250.

STEFFEN'S PROCESS FOR SEPARATING SUGAR FROM MOLASSES. PLAN OF FIRST FLOOR.

Scale: 1-100.

PLATE 4.



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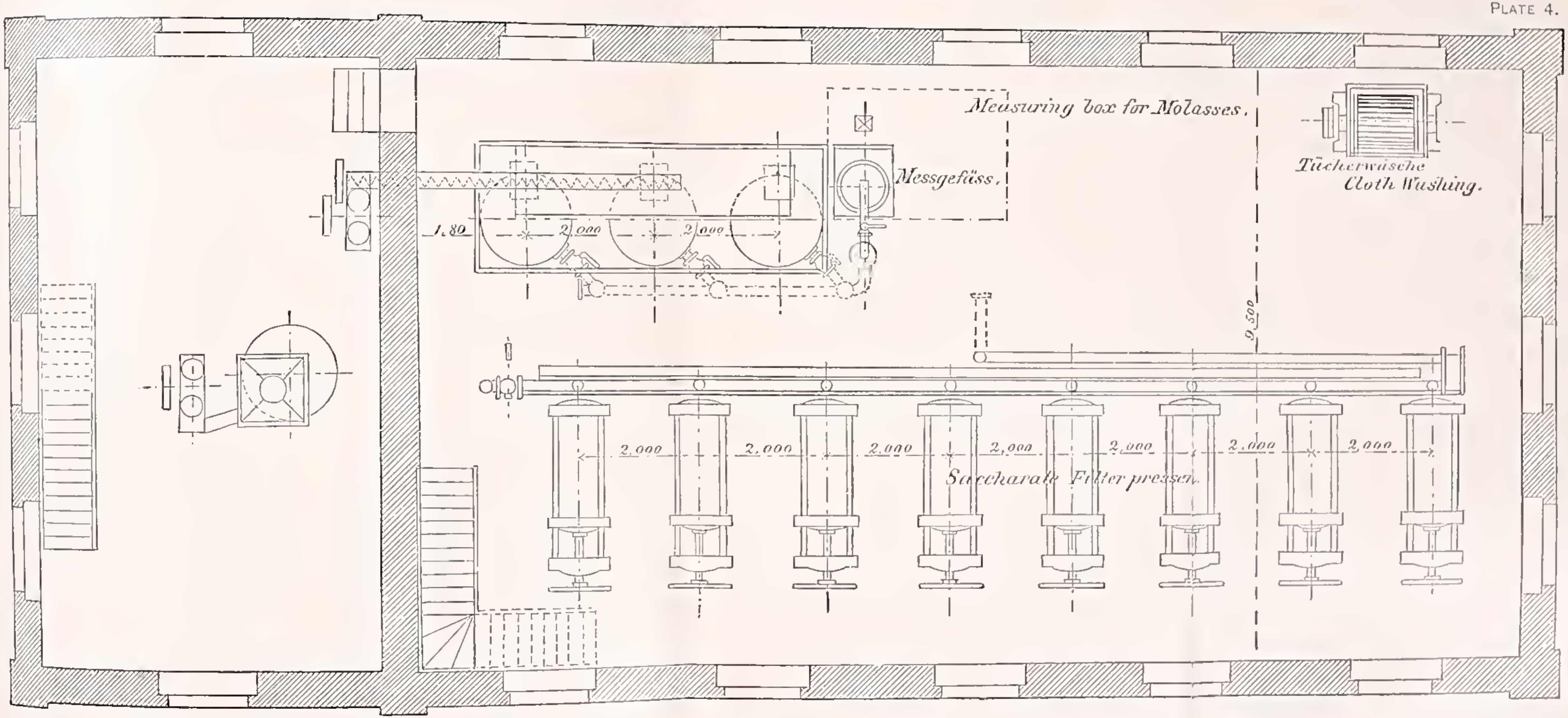

STEFFEN'S PROCESS. PLAN OF SECOND FLOOR.
Scale: 1-100.

(To follow Plate 3.)

PLATE 5.

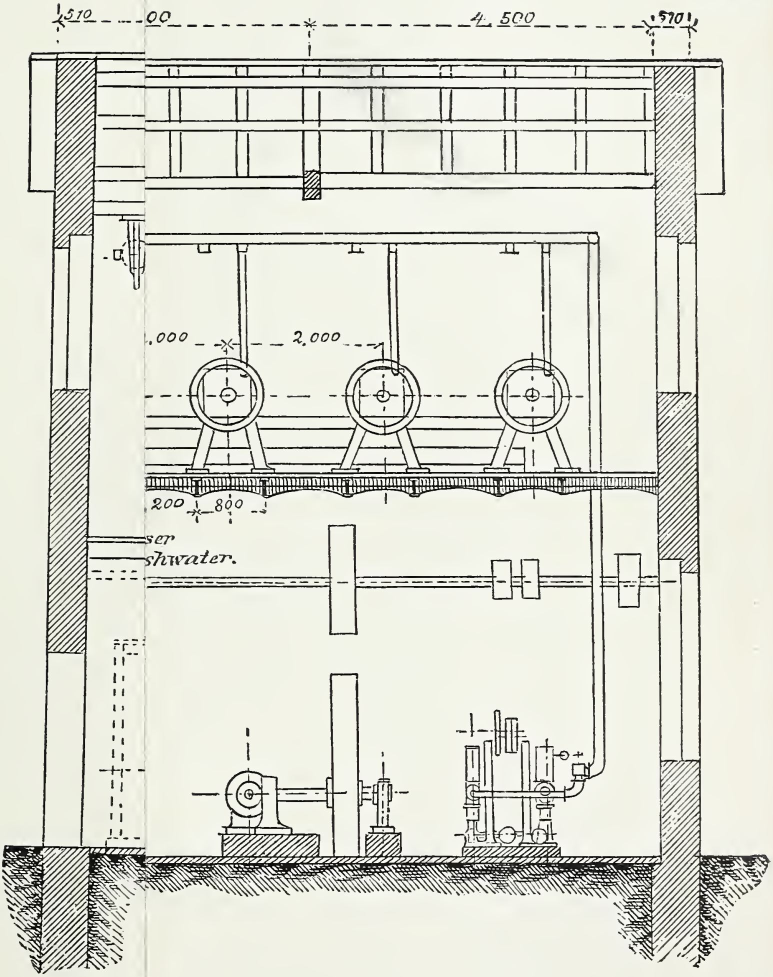

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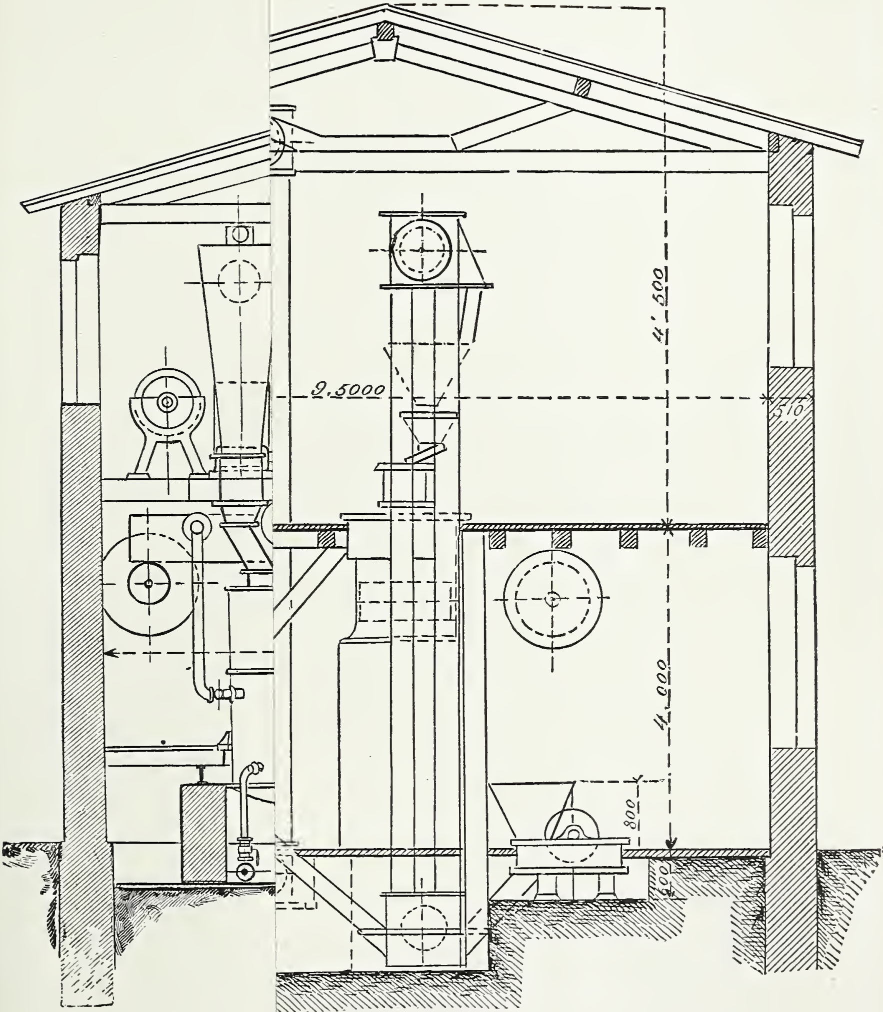
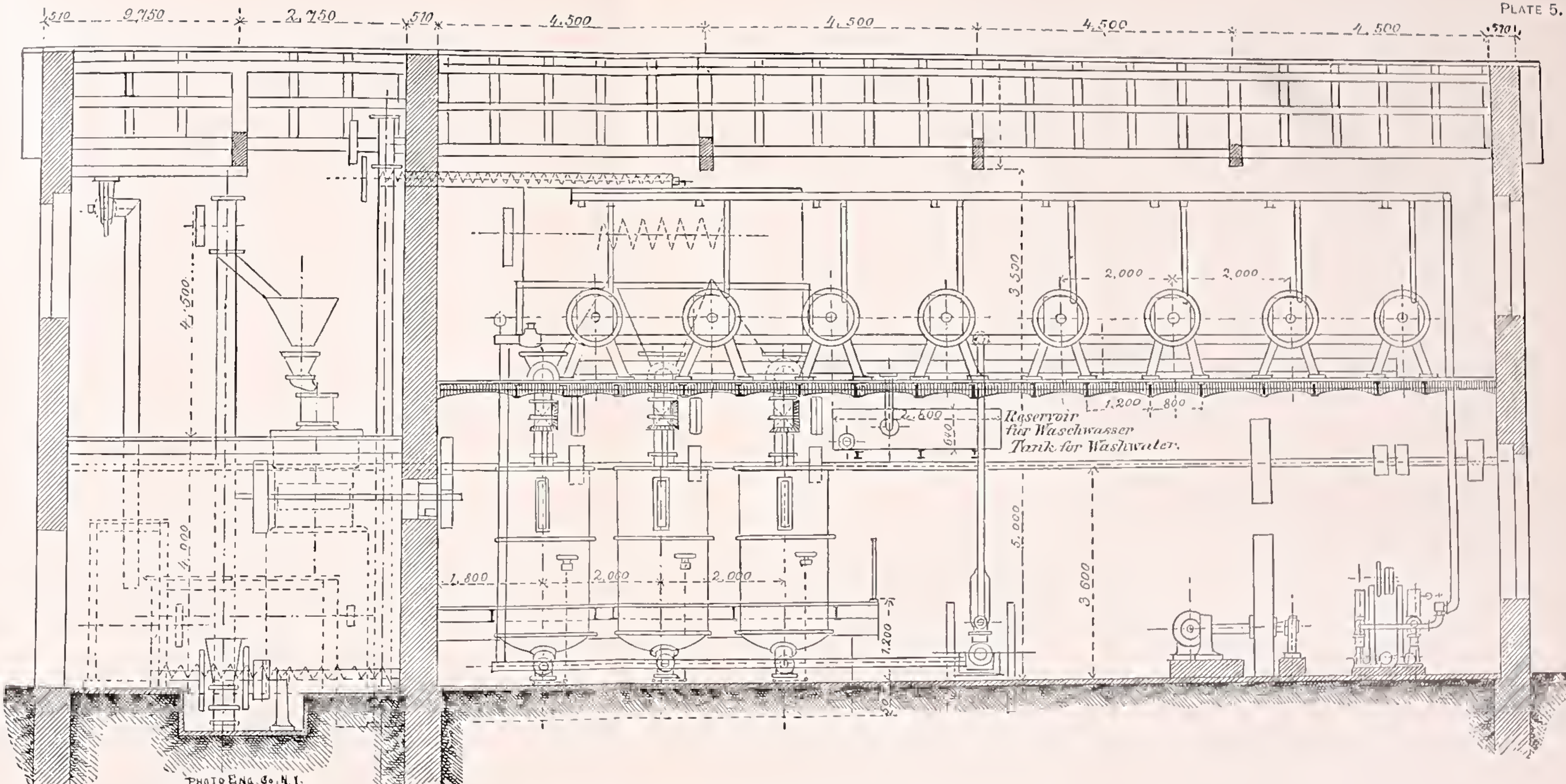
PLATE 6.



FEN'S PROCESS. END VIEW.

(To follow Plate 5.)



STEFFEN'S PROCESS. SIDE VIEW, SHOWING DISPOSITION OF MACHINERY.

Scale: 1-100.

(To follow Plate 4.)

(the weight of raw sugar added not being taken into account). The second molasses yielded 25.52 per cent. sugar, or 6.03 per cent. of the molasses originally taken. The total amount of first and second sugars extracted is 23.48, plus 6.03, and equals 29.48 per cent. The proportion of third sugar has not yet been determined."

REPORT ON THE TURKIEWITSCH METHODS OF DIFFUSION.

Turkiewitsch has proved that of all circumstances which insure good desaccharification of the chips, as number of cells composing the battery, temperature, and time of maceration, the last is the most important. To increase this factor, he replaces the long batteries by short ones. For a battery of twelve cells he substitutes two of six cells each. This causes an increase in the amount of beets worked and a heavier and purer juice. It also reduces the sucrose lost in the chips and the consumption of fuel to a minimum. Only slight changes in the connections and pipes are necessary to arrive at the desired result. The battery is operated in the following manner:

(1) The chips are cut so fine that 100 grams represent a length of about 40 millimeters.*

(2) The water should be heated to 30 or 40° R. and should enter the battery under a pressure of from 1 to $1\frac{1}{4}$ atmospheres.

(3) The cells should be filled and emptied as rapidly as possible.

(4) The temperature should always be lower than it is in the old system, and should vary with the kind of beet and the rapidity of work. The last cell (*i. e.*, the one just filled) is not heated and the juice passes from it to the measuring-tank at the same temperature at which it entered. Five is heated as soon as the required amount of juice has been drawn from 6. The cells are to be heated as follows:

42° 57° 60° 50° Réaumur.

(5) The heaters must not contain any water while the cells are being emptied.

(6) The work must be so regulated that while Cell 1 Battery I is being filled with chips, Cell 1 Battery II is emptied and washed. As soon as Cell 1 Battery I has been filled, juice is forced into it from below and Cell 1 Battery II filled with chips. When the latter has been filled, juice is forced into it and then in turn Cell 1 Battery I and Cell 1 Battery II are drawn off.

In actual practice the above method has been found to almost double the time of maceration.

* This corresponds to chips about 2 millimeters wide and $1\frac{1}{4}$ millimeters thick.

In the following tables are some average analyses made at the beet house Raigovad while working according to the new system:

Cells.	Specific gravity.	Degree Brix.	Sucrose.	Purity.	Temperature.
					°
1	....	....	....	....	....
2	1.0037	1.00	0.44	44.00	50.0
3	1.0015	2.95	1.84	62.30	65.7
4	1.0223	5.65	4.00	70.70	65.7
5	1.0380	9.65	7.16	74.20	65.7
6	....	11.80	9.80	83.10	50.0

The purity of the normal beet juice was 80.60. The following figures afford a comparison between the two systems:

	Beets ground per day.	Degree Brix, normal juice.	Sucrose in exhausted chips (95,5 per cent. juice).	Sucrose in waste water.	Degree Brix diffusion juice.
	Kilos.			*Per cent.*	
One battery of twelve cells	291,854	15.10	$\frac{0.31\times 95.5}{100}$	134×0.08	10.30
Two batteries of six cells each	352,433	15.40	$\frac{0.30\times 95.5}{100}$	119×0.08	11.60

Seventy-five per cent. of milled bagasse were obtained. The waste water showed 0.2° Brix; the juice from the exhausted chips 0.6° The beets contained 95 per cent. juice.

The dilution in both methods is calculated as follows:

A. *Long battery.*

$$75\times 0.6\%\times 95.5\% = 0.429$$
$$134\times 0.2\% = 0.268$$
$$\overline{0.697}$$

$$15.1\times 0.95 = 14.34$$
$$-\ 0.70$$
$$\overline{13.64}\text{ solids extracted.}$$

$$\frac{13.64\times 100}{10.3} = 132\text{ juice per 100 beets.}$$

B. *Short battery.*

$$75\times 0.6\%\times 95.5\% = 0.429$$
$$119\times 0.2\% = 0.238$$
$$\overline{0.667}$$

$$15.4\times 0.95 = 14.60$$
$$-\ 0.67$$

$$\frac{13.93\times 100}{11.6} = 120\text{ juice per 100 beets.}$$

During the last season the beet house Mirowoka ran for five weeks according to the old and the remaining thirty-six days according to the new system. The following table makes the advantages of the new system manifest:

System.	No. of days run.	Average daily run.	Normal juice.			Dilution per 100 beets.	Diffusion juice.			Sucrose lost.	Time of maceration in cell.	Fuel per cent. consumed beets.	Fuel in 24 hours per hl. cell content.
			Brix.	Sucrose.	Purity.		Brix.	Sucrose.	Purity.				
		Kilos.	*Per ct.*				*Per ct.*					*Per ct.*	*Kilos.*
Long battery.	36	275, 600	16. 41	12. 72	77. 43	166.	9. 33	7. 32	78. 46	0. 523	50.	12. 98	1338
Short battery.	86	324, 300	15. 61	12. 00	76. 85	132. 5	11. 06	8. 71	78. 89	0. 499	46. 2	11. 82	1504

It becomes apparent that the above house has increased (1) the daily amount ground by 17.4 per cent., (2) the diffusion juice by 24.33 per cent., (?) and has lessened the (3) volume of juice by 32.6, (4) consumption of fuel by 1.16 per cent., (5) while the juice has a higher purity and (6) the loss of sucrose has been reduced. We can safely assume that the new system increases the daily capacity of the house by 10 per cent.*

GENERAL PLAN OF SUGAR-HOUSE.

For the information of the many persons who have written for general intelligence in regard to a beet-sugar house, Mr. G. L. Spencer has prepared at my request the following plan for such a building. (Plates 7, 8, 9.)

It would be unnecessary in this place to give the general working details of such a building, since those who propose to build such houses would desire to modify them in so many cases that such a general plan in detail would be undesirable. What is given, therefore, is merely for the purpose of illustrating the principles upon which a beet-sugar factory should be built and the general arrangement and proportion of its various parts:

Ground floor. (Plate 7.)

1. Warehouse for sugars.
2. Packing room for sugars.
3. Space for eight centrifugals.
4. Centrifugal engine.
5. Hot room for low-grade sugars.
6. Elevator.
7, 8, 9. Vacuum pumps.
10. Carbonic-acid-gas pump.
11. Diffusion battery.
12. Hydraulic beet transporter.
13. Beet-washing apparatus.

*Sucrerie belge, No. 3, October 1, 1888.

14. Beet-elevator.
15. Driving-engine for cutters, etc.
16. Bone-black filters.
17. Room for treatment of bone-black preparatory to revivification.
18. Space for bone-black kiln.
19. Chimney.
20. Boiler-house and pump-room.
21. Lime-kiln.
22. Room for slaking lime.

Second floor. (Plate 8.)

1. Space for sugar-bins.
2. Room for first sugars.
3. Hot room for second sugars, etc.
4. Elevator.
5. Carbonatation pans.
6. Triple effect.
7. Bone-black filters.
8. Diffusion battery.
9. Pulp-room.
10. Chutes for use in removing pulps.
11. Beet elevator.
12. Space for filter presses.
13. Laboratory.

Third floor. (Plate 9.)

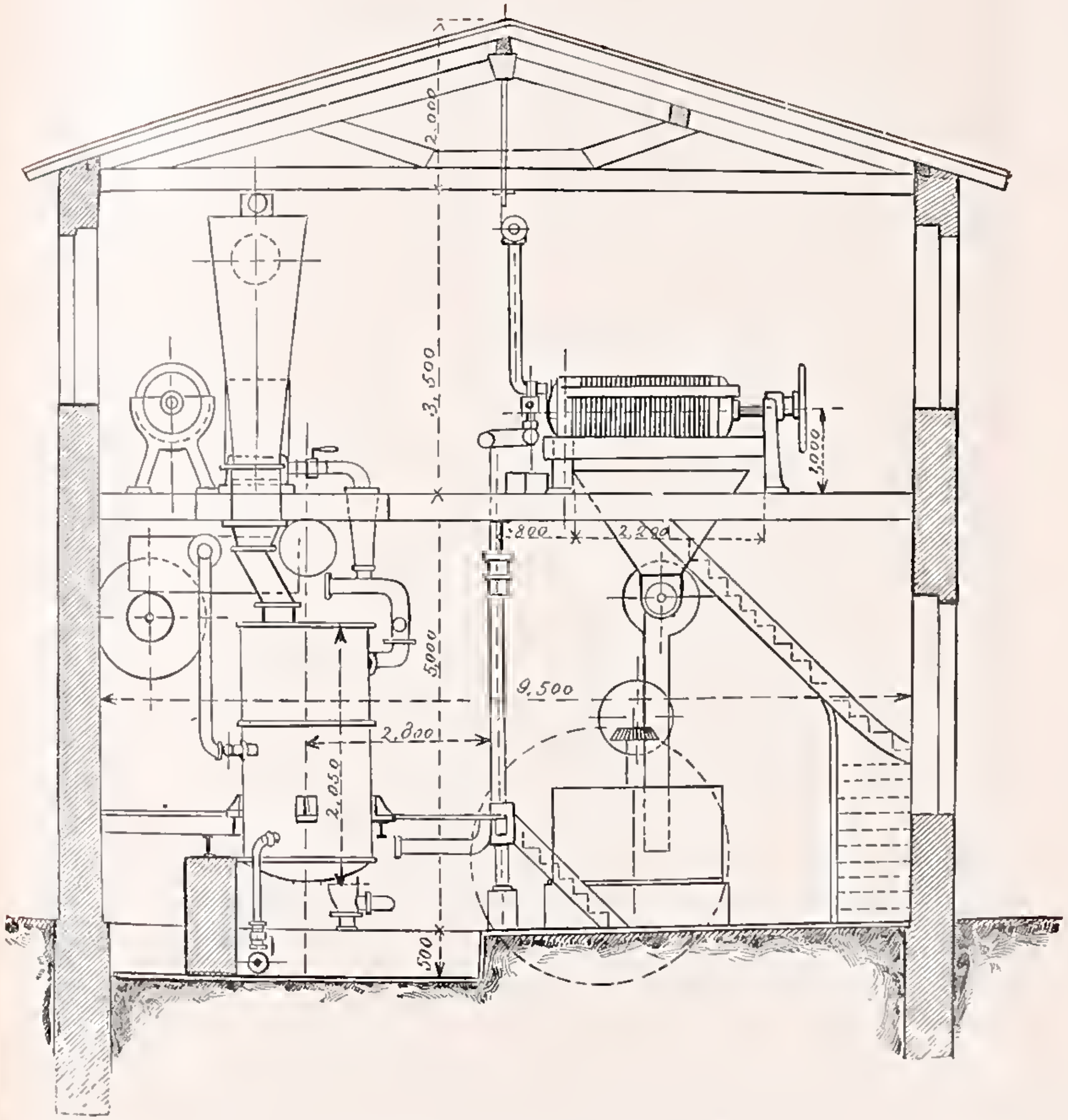
1. The vacuum pans discharging into wagons, etc., in the hot room as indicated by dotted lines from the pans.

The dotted lines (continuous with the main walls) indicate the location of the attics, which are high enough to accommodate projecting portions of the cutter and the pulp presses.

The general arrangement of a diffusion battery is shown in Plate 10, one of a sugar factory in Plate 11. These plates are taken from Bulletin No. 8, and are printed from plates furnished by the Fives-Lille Company, No. 84 Rue Coumartin, Paris, France.

COST.

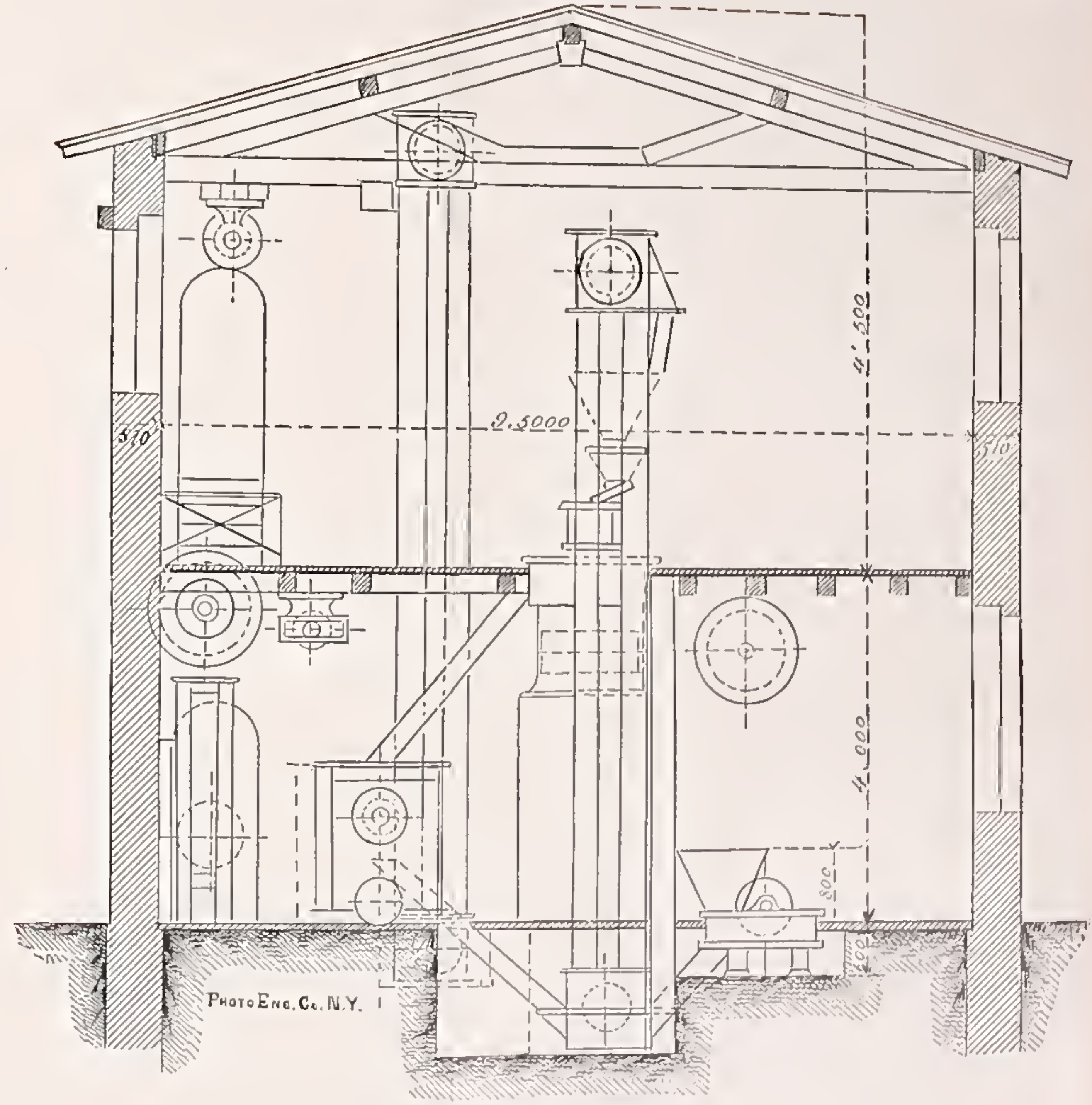
The cost of a beet-sugar factory depends on so many conditions that it will be impracticable to give anything more than a rough estimate of it. Much depends upon the character of the building itself, and this, for various reasons, should be made fire-proof, thus entailing the construction of a building of considerable cost. In regard to both the building and machinery, the total cost will depend largely upon the capacity of the house; the cost, however, does not increase in the same ratio as the capacity. In other words, it may be stated that the cost of a beet-sugar factory capable of working 400 tons of beets per day would not be double the cost of one working 200 tons. A beet-sugar house based on an estimated capacity of 300 tons per day would probably be more in keeping with the character of the houses which are to be built



STEFFEN'S PROCESS. END VIEW.

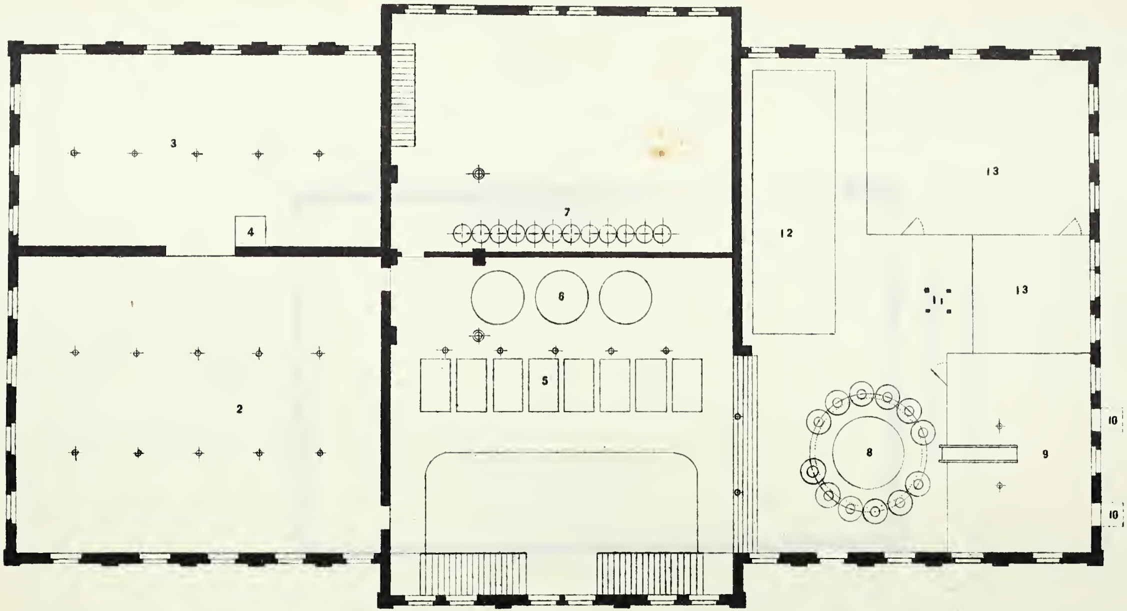
Scale: 1 100.

(To follow Plate 5.)



STEFFEN'S PROCESS. END VIEW.

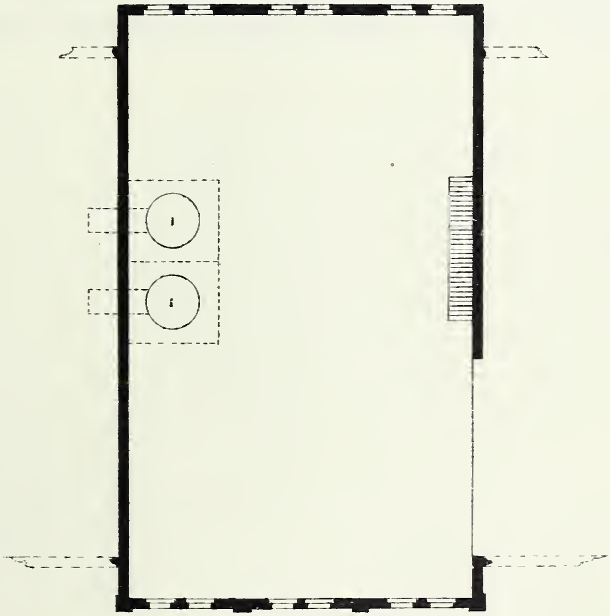
PLATE 7.



PLAN OF SECOND FLOOR.

– Scale – 1/32 in. to 1 ft. –

PLATE 8.



PLAN OF THIRD FLOOR.

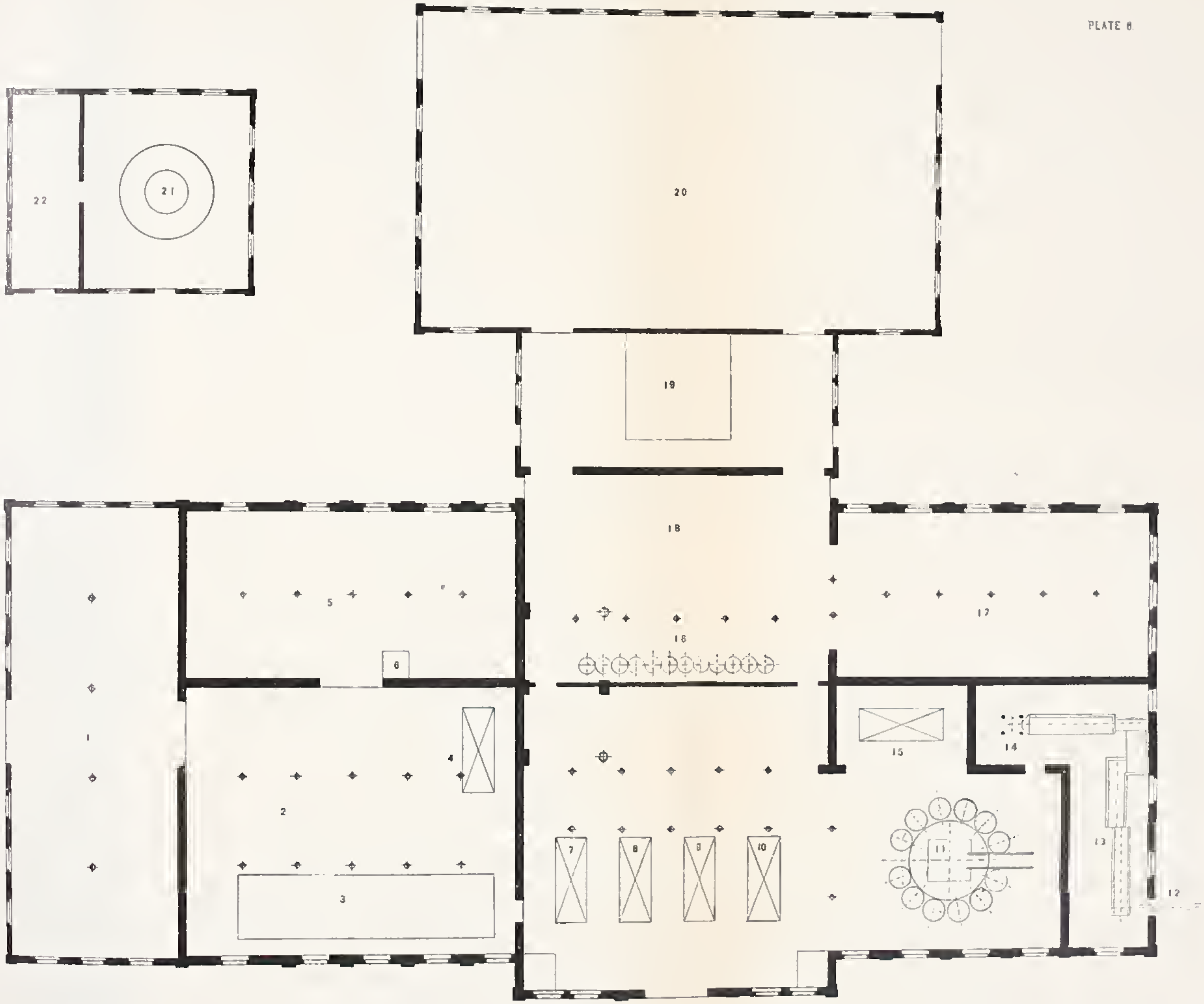
– Scale – 1/32 in to 1 ft. –

in this country for some time than any other. With a proper fire-proof building, and the best and latest machinery, such a factory would cost, ready for work, from $150,000 to $200,000. Factories, of course, can be built at a much less cost than this, but doubtless at the sacrifice of efficiency in some of its parts, so that true economy would advocate the construction of a high-priced factory of the best workmanship and of the most approved modern style.

Local considerations may also affect the cost of a factory, as distance of transportation of the machinery, nearness of iron and machine works, cost of land, etc. The Department has received many letters from persons conveying the impression that they have an idea that a beet-sugar factory can be built for a few thousand dollars, whereas it is seen from a general study of the problem itself that such a small outlay would be totally inadequate to secure a factory suitable for the work to be done.

PLATE 10.

PLATE 8.



PLAN OF FIRST FLOOR.

– Scale 1/32 in. to 1 ft. –

PLATE 11.

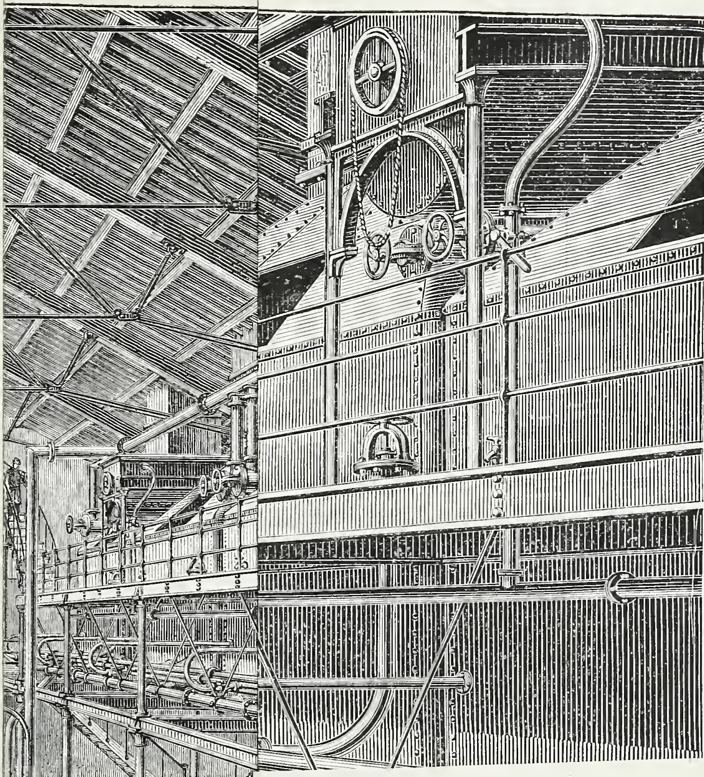
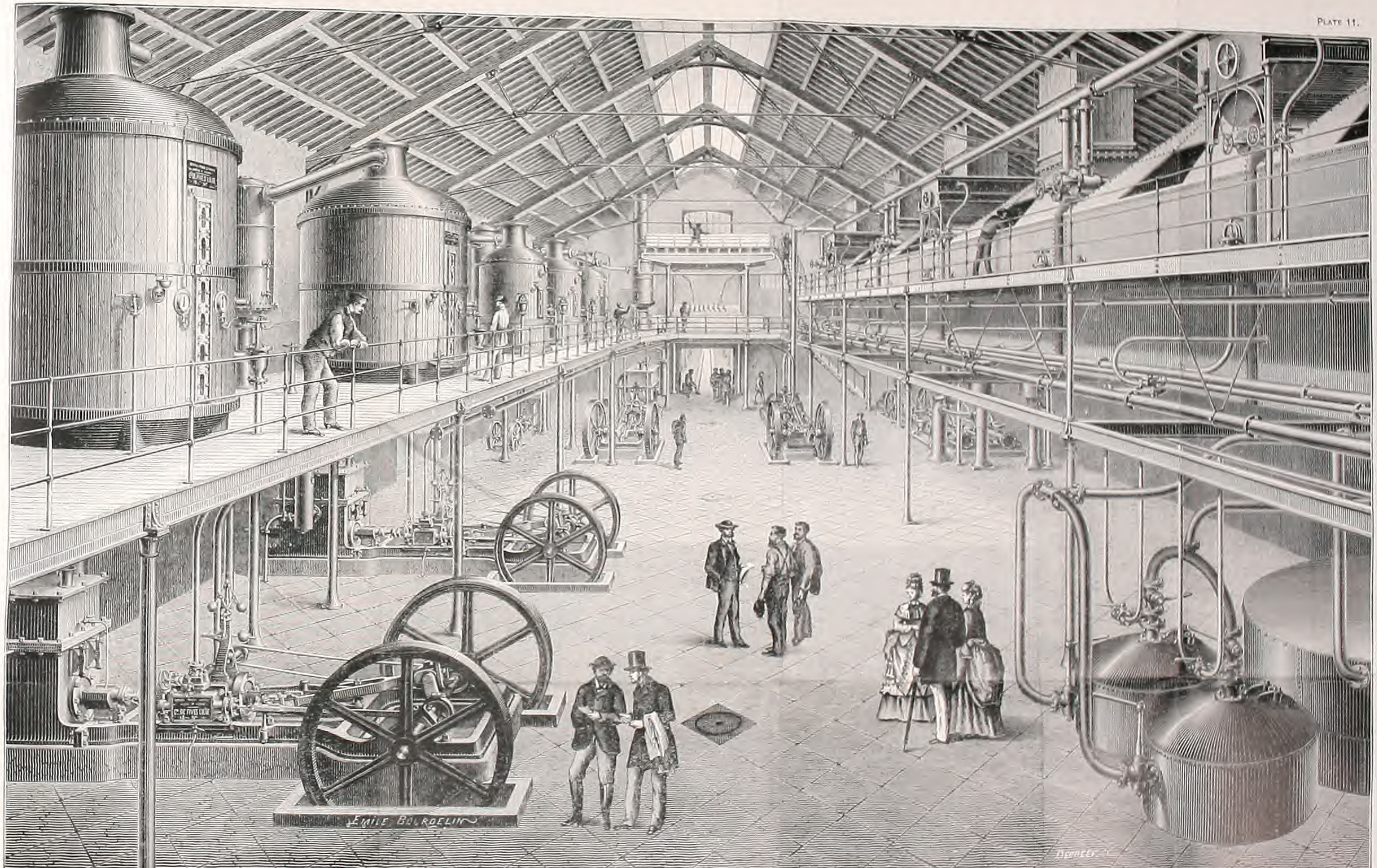
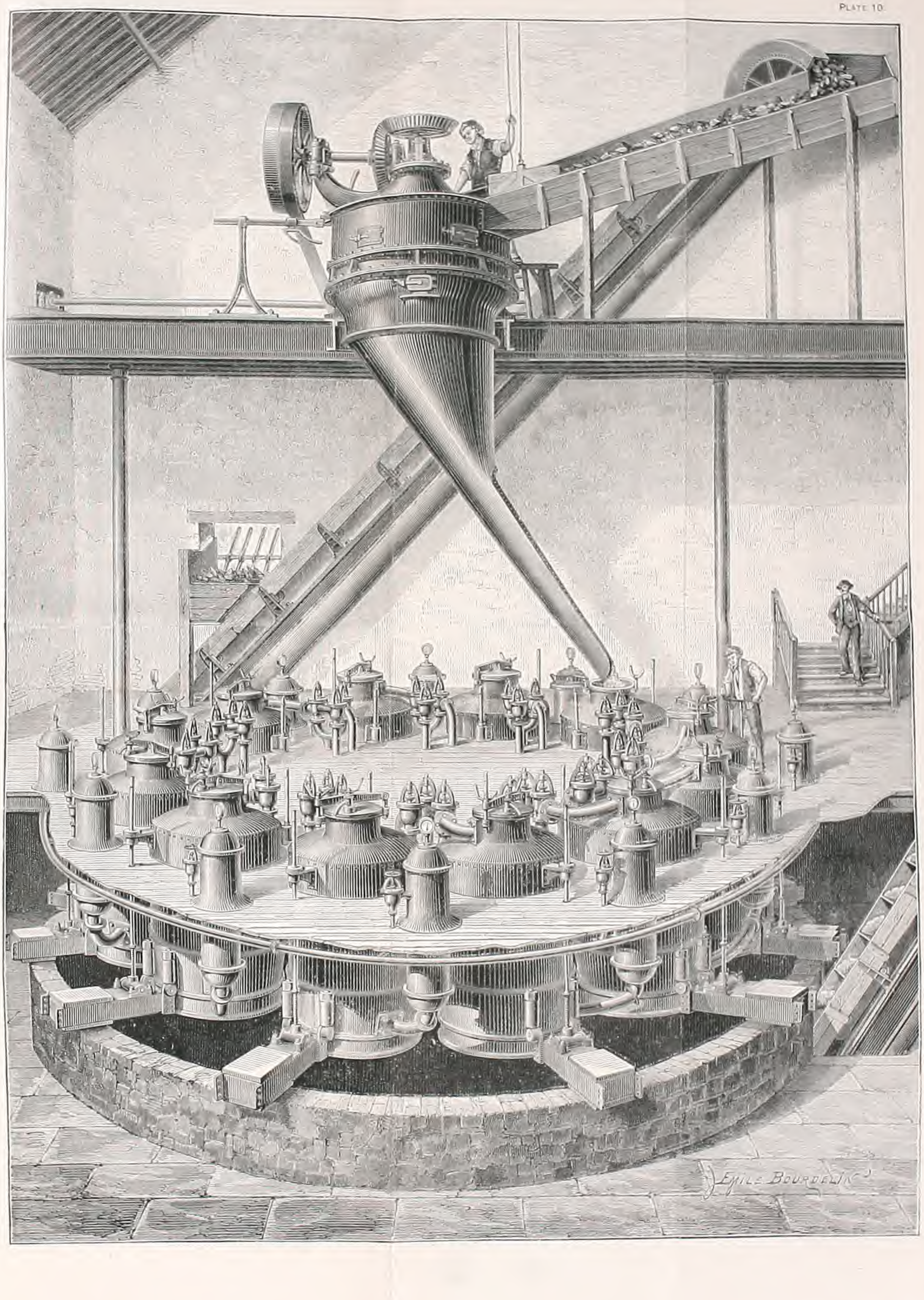


PLATE 11.




EMILE BOURDELIN

INDEX.

C.

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