The FRED. W. WOLF CO.

MANUFACTURERS OF

BEET SUGAR MACHINERY

139 Rees Street - Foot of Dayton

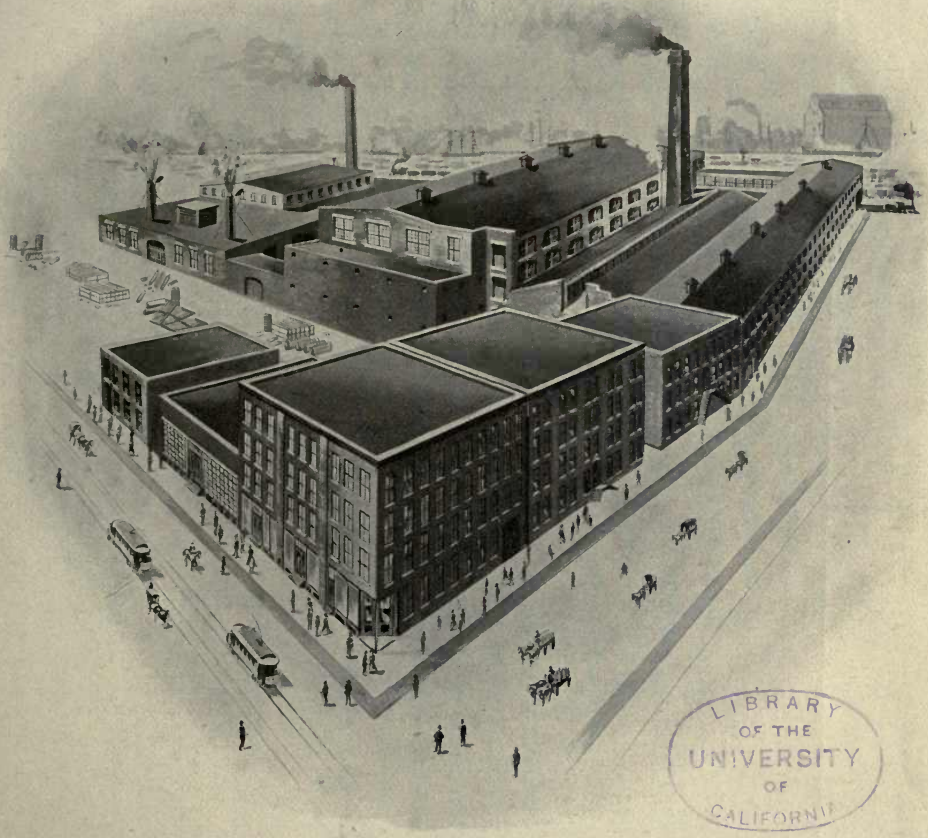
CHICAGO, U. S. A.

Yours truly
Fred. W. Wolf.

THE BEET SUGAR INDUSTRY

A SHORT TREATISE ON

SUGARBEET CULTURE AND THE MANUFACTURE OF BEET SUGAR



BY

THE FRED W. WOLF COMPANY

DESIGNERS AND BUILDERS OF
MACHINERY AND APPARATUS
FOR THE MANUFACTURE OF
BEET SUGAR

GENERAL OFFICES AND WORKS
139-143 Rees Street 302-330 Hawthorne Avenue
CHICAGO, U. S. A.

1899

AMONG

THE ILLUSTRATIONS

IN THE FOLLOWING PAGES WILL BE

FOUND EXTERIOR AND INTERIOR VIEWS OF THE FIRST

BEET SUGAR FACTORY ERECTED 1898 IN THE STATE OF MICHIGAN

DESIGNED, BUILT AND EQUIPPED BY

THE FRED W. WOLF COMPANY

FOR THE

MICHIGAN SUGAR CO., BAY CITY,
MICHIGAN . . . Daily Capacity 450 Tons.

ALSO INTERIOR AND EXTERIOR VIEWS OF

THE DETROIT SUGAR COMPANY'S FACTORY, ROCHESTER, MICHIGAN,
Daily Capacity, 500 Tons, and the Factory of the

KALAMAZOO BEET SUGAR CO., KALAMAZOO, MICH.,
Daily Capacity 500 Tons

ERECTED IN

1899

THE FRED W. WOLF CO.
ENGINEERS AND MACHINISTS
GENERAL OFFICES, 139-143 REES STREET
CHICAGO, U. S. A.
POSTAL TELEGRAPH LINES IN OUR OFFICE
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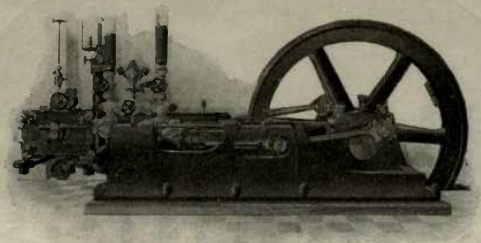


THE LINDE

MANUFACTURERS OF
REFRIGERATING MACHINERY AND AMMONIA FITTINGS
ICE PLANT SUPPLIES AND AMMONIA
AGREEMENTS CONTINGENT UPON DELAYS BEYOND OUR CONTROL
ADDRESS ALL COMMUNICATIONS TO THE COMPANY

CHICAGO, May 10, 1905.

Mr. J. C. Rowell,
c/o University of California,
Berkeley, California.

Dear Sir:

Replying to your letter of 6th inst., we are pleased to send you under separate cover one of our Beet Sugar Machinery Catalogues, which we trust will be of interest to you.

Kindly acknowledge receipt of same, and oblige

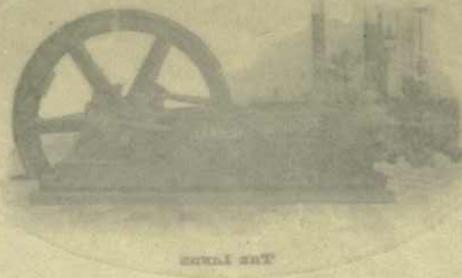
Yours very truly,

THE FRED. W. WOLF COMPANY,

per Carl P. Bowden

FC

THE FRED W. WOLF CO.



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Per [illegible]

FC

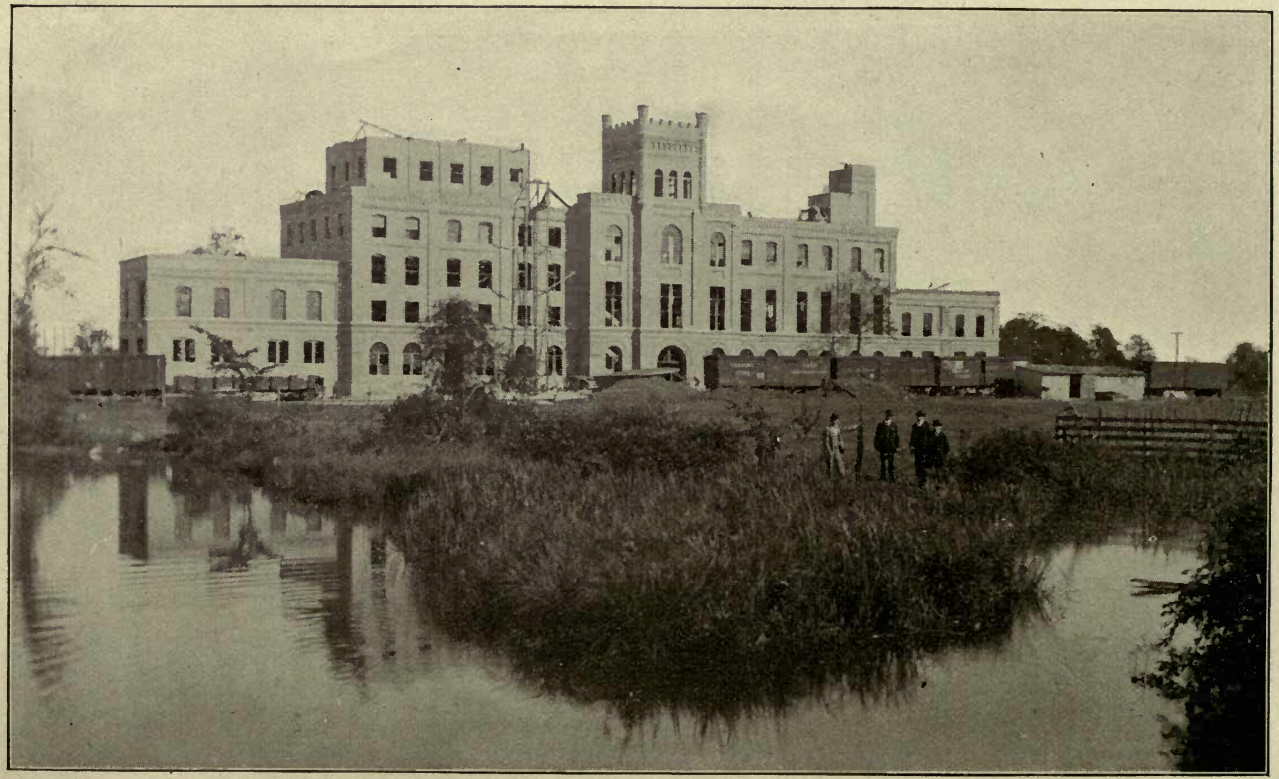
PREFACE.

In offering this little book to the intending beet grower, the capitalist wishing to invest money in this new and promising industry of manufacturing sugar from beets, we do not lay claim to present a scientific work, covering in detail every feature of the beet sugar industry. Our object simply is to explain, in condensed form, the main feature of the subject and to offer reliable help and counsel to the farmer who wishes to raise beets and the capitalist who is to manufacture them into sugar.

The Sugar Department of The Fred W. Wolf Co., with its large staff of experts is in a position and stands ready at all times to assist by deed and counsel, all those who desire to engage in the beet sugar industry. The company will contract to furnish the machinery for, or erect sugar factories complete in every detail and will take it upon itself to furnish the skilled labor necessary for their successful operation. If desired the company will also put the factories built by it in operation, or conduct the first working campaign from start to finish, guaranteeing to turn out the best marketable product.

We hope that our aim, presented by the following pages, to promote the introduction of this new and promising industry, will meet with intelligent understanding and enable those who wish to participate in it to save money.

THE AUTHORS.



DETROIT SUGAR CO'S FACTORY AT ROCHESTER, MICHIGAN, DURING ERECTION.

Part I.

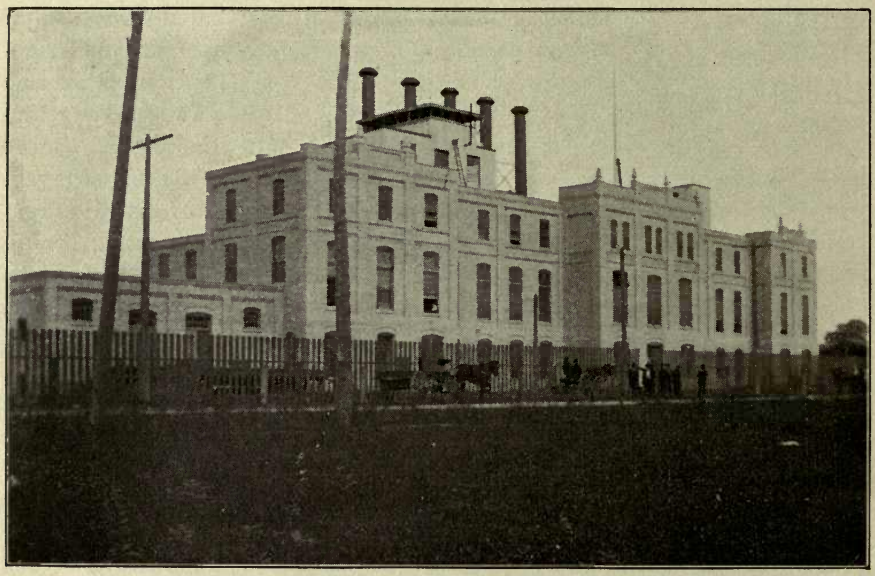
HISTORY OF THE INDUSTRY.

GENERAL HISTORY OF BEET SUGAR

On the 11th of January of this year the Beet Sugar Industry celebrated its 100th anniversary in Germany, the land of its cradle, from whence it spread in a comparatively short time all over Europe, developing in a most wonderful industrial power. More correctly the birth of the Beet Sugar Industry dates back in the year 1747, when the German chemist Margraf published the result of his investigations regarding the availability of certain beet varieties as sugar producers. However these investigations did not lead to any practical result, and it was left to Franz Carl Achard, director of the Royal Prussian Academy of Sciences, to repeat and expand Margraf's investigations, and to demonstrate not only the presence of crystalline sugar in certain beets, but also the feasibility to extract this sugar on a paying scale. Achard therefore may justly be called the father of this industry, which has proven of such immense value to the agricultural and industrial interests of all Beet growing countries. One may well doubt that Achard, when one hundred years ago, making his report to King Frederick William III, concerning the extraction of sugar from beets, ever supposed that his efforts were laying the cornerstone of an industry of its present magnitude. Achard's report resulted in a goverment order, that beets should be raised in large quantities in all provinces, and the establishment in 1799 of the first beet sugar factory upon his own property at Kunern, near Steinan, in lower Silesia. Up to the time of Achard's invention sugar had always been very expensive. The possession of sugar in the middle ages signified a princely fortune. Thus it is related, that the third wife of Charles V at her death left four small sugar cones, weighing each five pounds. Even at the time of Achard, one pound of sugar cost from $1.50 to $2.00. Still Achard's efforts might have been lost in oblivion, as the cost of production was considerably in excess of the price of the product, had it not been for Napoleon I, who in order to cripple and destroy English commerce, ordered and maintained a blocade of continental parts of Europe againist English colonial products. This

gave a fresh stimulus to the erection of additional factories in Saxony, Silesia, Bohemia, Austria, and especially in Belgium and France.

The success of these factories, and their threatened competition with colonial sugar, England's monopoly, spread great alarm under the English importers, and large sums of money were offered to Achard in order to induce him to repudiate his invention. They wanted him to publish a work, stating that his enthusiasm for beet sugar had deceived him, and that his experiments on a larger scale had shown him that beet sugar could never replace cane sugar. They are said to have offered him at first $50,000, and later even $200,000, but he refused to retract. Neither threats, blandishments, nor bribes availed with him. The English importers aided by the English colonial office left nothing



MICHIGAN SUGAR CO'S FACTORY, BAY CITY, MICHIGAN.
FRONT VIEW.

untried in their efforts to kill the beet sugar industry in the bud. They went that far, as to induce the best known savants of the day, even such a man as Sir Humphrey Davy, to write treatises in which the new invention was ridiculed, the product decried, and the most direful results predicted.

Verily, "history repeats itself" it is a wise teacher and wise people will ponder over its lessons and read wisdom therefrom. May not the pioneers of the beet sugar industry in our country, where we are still in the pioneer stage, be encouraged and justly so by Achard's example.

Although in the early days of beet sugar, the product amounted to but two to three per cent of the original weight of the beets, the facto-

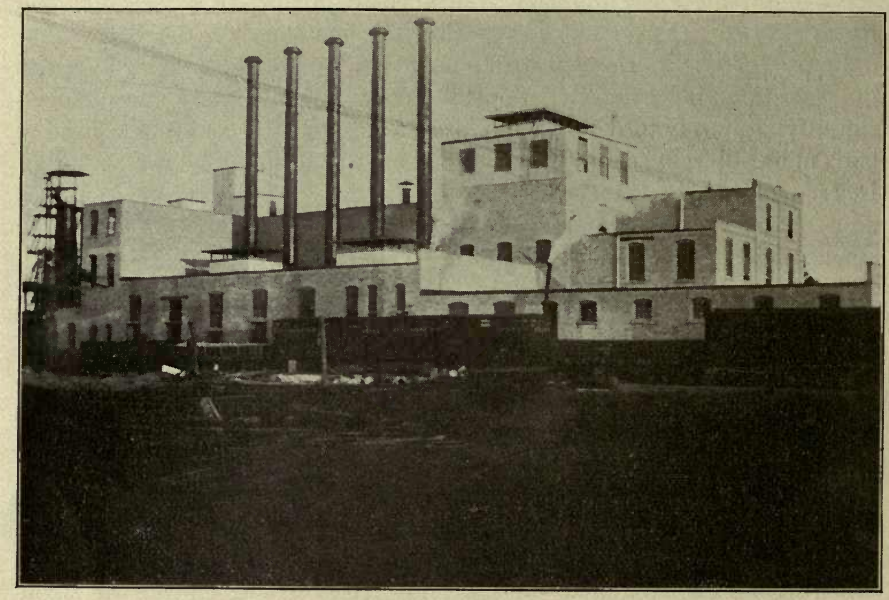
ries soon stood on a paying basis, owing to the high price to the product commanded. This was especially the case in France, where under the powerful patronage of Napoleon the industry made rapid strides. After the downfall of Napoleon and the removal of the continental blockade the beet sugar industry in Germany, owing to the renewed competition of colonial sugars became less prosperous. Colonial sugar became cheaper and cheaper, and notwithstanding the improvements in the chemical, technical and mechanical branches of the beet sugar manufacture the return was still so limited, that the manufacturers could not cope with the colonial competitor. They lost money, and as a consequence many factories closed down for good. In France, partly owing to improved methods of manufacture devised by French chemists, and partly as a consequence of the national antipathy to England and English products the industry continued to prosper in a measure, and from 1812 to 1836 France was the chief nursery of the beet sugar industry. In 1828 there were already 103 smaller beet sugar factories in operation in France. Constant and diligent study, resulted in simplifying and improving the process of manufacture and increasing the percentage of refined sugar originally obtained from the raw material. Instead of two to three per cent, as much as five and six per cent was now obtained and the production of beet sugar rapidly increased, amounting to about 40,000 tons in 1835.

In the meanwhile the industry had struggled along slowly in Germany, but in the early thirties it received a fresh impetus.

In 1834 three men, Zier, Hanewald and Arnoldi, associated themselves in Onedlinburg for the purpose of building and starting sugar factories on a paying basis. This trio of promotors succeeded to allure by brilliant promises many capitalists of their day to invest money in the industry. They built quite a number of factories, but it is not recorded that a single one of them turned out a howling success. But this was not so much the fault of those early promotors of beet sugar enterprises, as owing to the fact, that the chief principles of the culture of sugar beets and the art of sugar making was not as yet fully understood.

Agricultural methods especially were as yet in a very primitive stage, and it proved especially difficult to obtain good beets. The saccharometor having not yet been invented, it was almost impossible to tell good beets from poor ones. But both in field and laboratory improvement followed upon improvement. One of the foremost champions of the sugar industry, the chemist Franz Schatten, who was associated originally with Fritz Wrede in Halberstadt, then with Weihe in Wegeleben and last with Schreiber in Hermigen, about this time constructed the first saccharometer for ascertaining the amount of sugar in beets, the principle of his apparatus being based upon the formation of lime sugar, and the determination of the sugar content by titration

with acids. Of course his apparatus is no longer in use, but in his time it was a great boon to the industry. Schatten also constructed the first apparatus for the examination of bone coal as to its contents of lime. His process of revitalizing bone coal, and his bone furnaces are to this day in use in many sugar factories. The use of carbonic acid in treating the sugar juice is likewise one of Schatten's inventions, and to his zeal and genius the remarkable progress of the sugar industry in Germany is mainly due. At the beginning of the forties he and others, (we only name: Marker-Halle, Schulz-Lupiz, Schinner-Neuhaus, and Ring-Duppel), by scientific researches and practical experiments had demonstrated the fact, that from properly cultivated beets from six to eight per cent refined sugar were obtainable. The high protective tariff which



MICHIGAN SUGAR CO.'S FACTORY, BAY CITY, MICHIGAN.
REAR VIEW.

was placed at the time upon foreign sugars served as a further incentive for the growth of the industry. Germany in one bound took the lead as the beet sugar producer of Europe, and has held this place ever since, outdistancing all competitors. Aided by adequate legislation within a comparatively short time the industry assumed larger proportions until it became a potent factor under the agricultural and manufacturing industries of the land.

According to the official "statistical year book of the German empire, XV year", there were in operation:

WORKING SEASON	NUMBER OF FACTORIES	QUANTITY OF BEETS WORKED	AVERAGE WORKED PER FACTORY
		TONS	TONS
1873-74	337	3,528,764	10,471
1883-84	376	8,918,930	23,718
1892-93	401	9 811,940	24,466

From this it will be seen, that while during the twenty years 1873-74 to 1893-94, the number of factories only increased nineteen per cent, the quantity of beets worked increased 178.1 per cent. At the beginning of said period each factory worked up on an average of 10,471 tons, while at the end already 24,466 tons were worked up by each factory. Still more important was the increase in the output of refined sugar, owing to improved methods of beet culture, resulting in production of beets of higher sugar content, and the improvement in the process of sugar manufacture.

In 1873-74 the product amounted to 291,041 tons; in 1892-93 to 1,175,137 tons, or four times the former amount; in 1873-74, 12,12 kilos. were required to produce 1 kilo. of sugar; in 1892-93 only 8,35 kilos, were required to produce 1 kilo. of sugar. Germany has now over 400 beet sugar factories contributing in round figures 2,000,000 tons, (about three-quarters of which is exported to other countries), out of a total annual production of Europe amounting to nearly 5,000,000 tons, or two-thirds of all the sugar produced in the world.

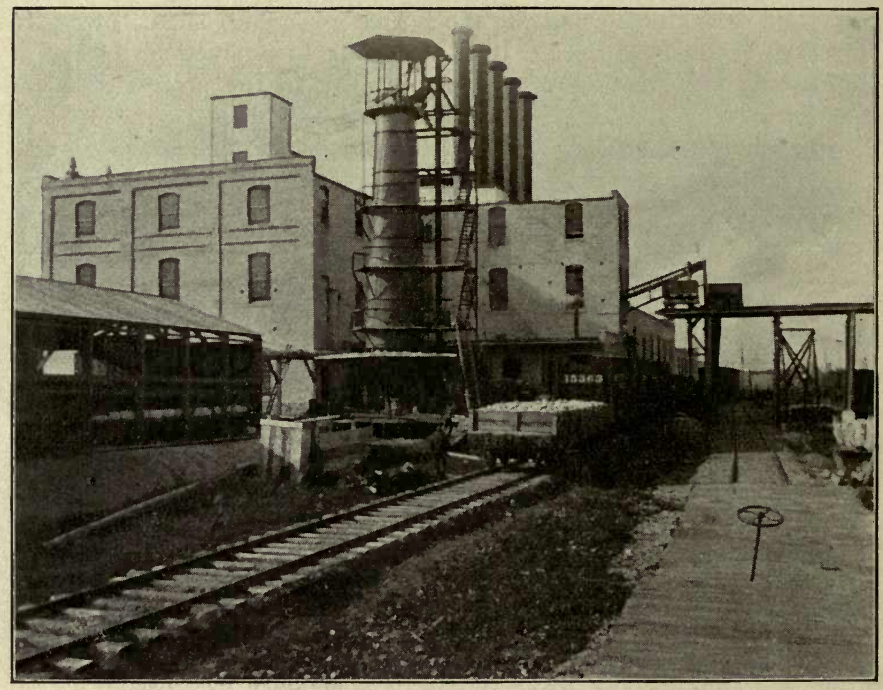
Germany alone produces the amount equal to the present total annual imports of sugar in the United States. From the same official source already mentioned we obtain the following data concerning the beet sugar industry in Germany for the two seasons.

	1897-98	1896-97
Factories in operation	402	399
Refineries in operation	50	51
Total beet area, (acres)	1,080,256	1,049,456
Average yield per acre, (tons)	1,222	1,283
Beets worked, (tons)	13,697,891	13,721,691
Total sugar production, based on raw sugar, (tons)	1,844,379	1,821,223
Sugar in beet, (per cent)	12.79	12.66
Field of sugar per acre, (pounds)	3,763	3,851
Imports of sugars, (tons)	1,298	1,532
Exports of sugars, (tons)	1,087,049	1,310,713
Domestic consumption, (tons)	708,237	561,889
Consumption per capita, (pounds)	259	202
Consumption tax	$32,626,230	$29,643,148
Import duty	105,910	142,800
Export bounty	8,724,142	5,083,756
Net profit	24,007,208	21,702,192

In this connection the following data pertaining to number of factories, yield of beets per acre, yield of sugar, etc., in the principal beet sugar producing countries, 1895-96, may be of interest.

Germany Number of factories 397; beets worked 10,589,413 tons; number of acres cultivated 930,245. mean yield per acre 13.8 tons; mean price of beets $4.64 per ton; yield of raw sugar 13.11 per cent. on weight of beets; average output of raw sugar per factory, 3,690 tons.

France Number of factories 356; beets worked 4,909,221 tons; yield of refined sugar 10.97 on weight of beets; number of acres cul-



MICHIGAN SUGAR CO.'S FACTORY, BAY CITY, MICHIGAN.
REAR VIEW—SHOWING LIME KILN.

tivated 405,852; yield of beets 9.5 tons per acre; average output of refined sugar per factory, 1,702 tons.

Austria-Hungary Number of factories 216; beets worked 5,225,390 tons; yield of raw sugar 13.5 per cent. on weight of beets; averege output of raw sugar from each factory, 3,323 tons.

Russia Number of factories 273; beets worked 4,818,869 tons; per cent. of raw sugar in beets 15.71; average output of sugar for each factory, 2,565 tons.

From these figures the observant reader may form some conclusions as to what the industry might amount to in the United States, if established on a scale to produce all the sugar required for home consumption. Perhaps the best demonstration of the importance of the beet sugar industry is presented by the fact that after its few decades of existence in Germany and comparatively small sacrifices by the government and private individuals, it is now able to pay over $32,000,000 annually in taxes to the state. Large as this sum may appear it is nothing compared with the wealth the industry has brought to the nation.

HISTORY IN THE UNITED STATES

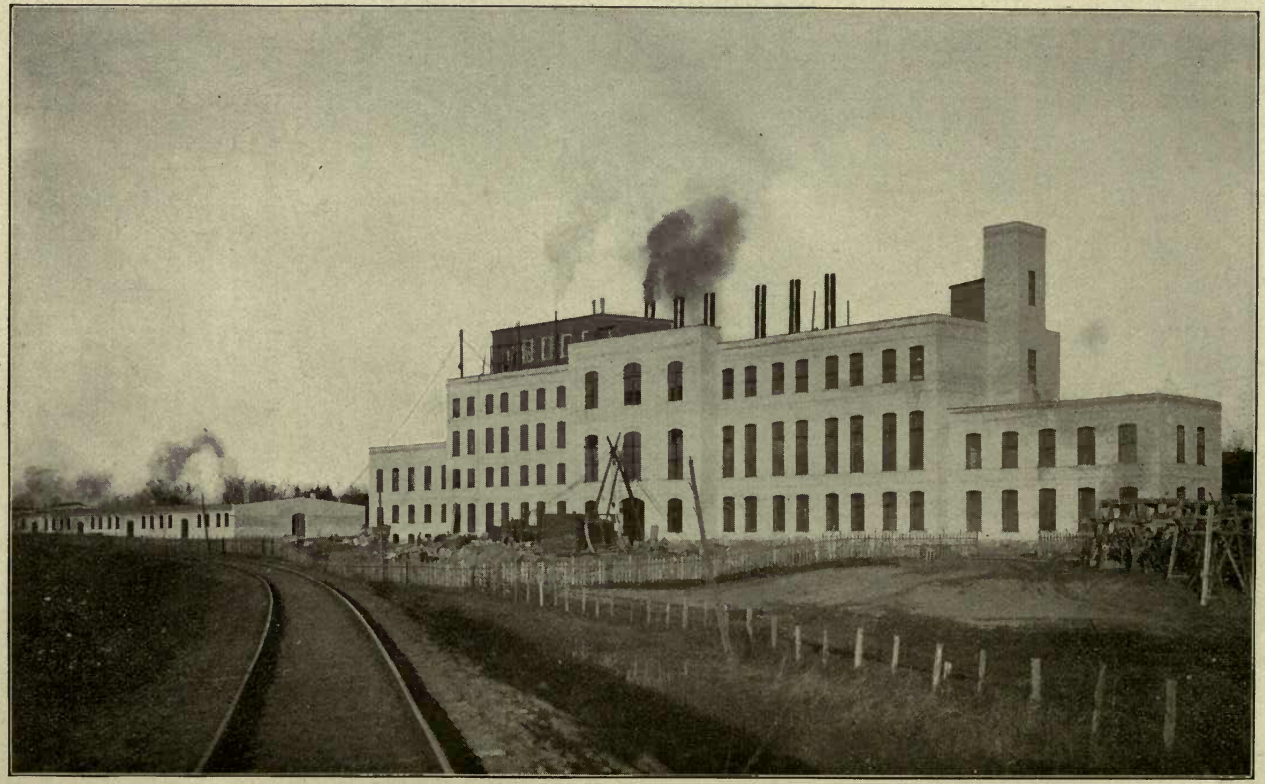
It seems rather remarkable that with the example set before our eyes by Europe, and its experience, covering ing half a century, at our command, the early career of the beet sugar industry in our country should have been marked by a succession of failures.

The first efforts at sugar beet growing in this country were made in the year 1830 by two Philadelphians. Eight years later, in 1838, Dav. L. Child at Northampton, Mass., experimented with beet raising and the manufacture of sugar. His method consisted in drying the roots and then extracting the sugar therefrom. It was not a brilliant success, and about 1,300 pounds were made in this way. There was then an interim of active interest till 1863, when two German brothers by the name of Gennert began the manufacture of sugar at Chatsworth, Ill., (100 miles south of Chicago). This undertaking collapsed after six years, owing to unfavorable local conditions, mainly lack of water.

The plant was then removed to Freeport, Ill., where it was likewise unsuccessful. In 1870 the brothers located at Blackhawk, Wis., but shortly afterwards sunk from sight.

Thus the industry during the first forty years of its history in the United States proved a failure. The first successful undertaking was that by Bonestell & Otto, two Germans who organized a company with a capital of $12,000, which operated for two years a small factory at Fond Du Lac, Wis. These works were then abandoned, Bonestell & Gtto accepting an offer from the Alvarado Sugar Company, Alvarado, California, where they continued to operate until 1873. Subsequently Mr. Otto went to Santa Cruz county, where he operated a factory until 1876. The Alvarado factory failed in that year, but was reorganized in 1879, and has been in succesfsul operation ever since. The success of this factory and of six others, established up to 1896, (of which three were situated in the State of California, two in Nebraska, one in New Mexico), demonstrated beyond the shadow of a doubt, that beet culture and the manufacture of sugar from beets could be carried on successfully in the United States.

Why neither private capital up to this time worked this great industrial domain properly, nor the government did consider it necessary prior



KALAMAZOO BEET SUGAR COMPANY'S FACTORY IN COURSE OF CONSTRUCTION.

to the enactment of the Dingley law, July, 1897, to protect and foster this industry, is a question of a delicate nature, a discussion of which would transgress the scope and tendency of these pages.

Suffice it to say, that up to 1890 nearly nothing was done in the United States, and in the seven years following there were erected in this great country but seven factories, with a maximum annual output of about 40,000 tons. The following table shows the increase in production from year to year:

Production of Beet Sugar in the United States from 1830 to 1896.

(From the Weekly Statistical Sugar Trade Journal.)

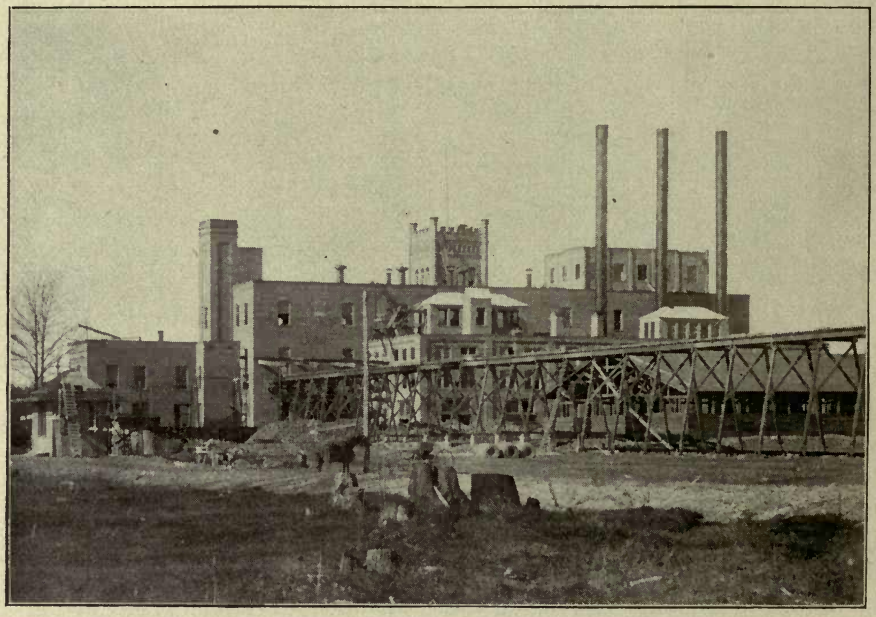
1830, a few hundred pounds.		1884	953 tons.
1831–37, none.		1885	600 tons.
1838–39	1,300 pounds.	1886	800 tons.
1839–62, none.		1887	255 tons.
1863–71, 300 to 500 tons per annum.		1888	1,010 tons.
1872	500 tons.	1889	2,600 tons.
1873	700 tons.	1890	2,800 tons.
1874–77, under 100 tons per annum.		1891	6,359 tons.
1878	200 tons.	1892	12,091 tons.
1879	1,200 tons.	1893	20,453 tons.
1880	500 tons.	1894	20,443 tons.
1881–82, less than 500 tons.		1895	30,000 tons.
1883	535 tons.	1896	40,000 tons.

All the signs of the time indicate that we are now on the verge of a much greater, more healthful and more rapid development. It is indeed a wonder that this industry has not attracted greater attention heretofore, considering the far reaching consequences, possibilities and opportunities which it involves for the farmer, sugar manufacturer and the many trades that would directly or indirectly benefit by its growth. Extensive tests made for a number of years by private parties and by our government, in various parts of the country, have demonstrated clearly and beyond a doubt, that the sugar beet can be raised successfully in nearly all the states of the Union. This is no more an open question. But furthermore, it has been demonstrated that we can and do raise better beets, *i. e., of a higher percentage of sugar and greater purity than can be raisid in any part of the old world.*

(In a report made by the United States Consul Brittain at Nantes, made to the Department last October, the average percentage of sugar in the beet in various countries is given as follows: France 11.95; Belgium 13.75; Holland 13.80; Germany 13.50; Austria-Hungary 13.; Russia 12.40; Sweden 13.; Denmark 12.)

Sugar beet culture is now making rapid strides in this country, for we have finally awakened to the fact that it is sure to promote our agricultural, manufacturing and entire economic interests in a degree as no other product will. It is of equal interest to the farmer as to the

manufacturer and capitalist. It means employment to idle capital and labor. With its advent and progress we are bound to witness an increase in agricultural wealth beyond expectation. It will enhance the value of farm lands, not only by reason of its yielding more profits than any other plant, but also on account of the benefit accruing to the other crops, by superior cultivation and improved rotation. It will enable the farmer to diversify his crops, and enable the sugar manufacturer to buy his raw material in the home market, instead of sending over one hundred millions of dollars for it every year to foreign countries. We have the soil and the climate; we have intelligent farmers and we have intelligent mechanics, and the one thing that has hitherto stood in the way of a more



DETROIT SUGAR COMPANY'S FACTORY, ROCHESTER, MICHIGAN.
REAR VIEW.

rapid development of the sugar beet raising and beet sugar industry was the fact that capital had not become sufficiently interested in it. The farmer is simply waiting for the capitalists to say the word, to plant a portion of his fields in *well paying beets*, instead of having to use them in planting *low priced wheat and corn*. It is, for instance, a well known fact that in what is known as the large corn belt of this country, the farmers received for their crops 1895–96 during several months only 8 to 12 cents per bushel. This low priced product was exported, while the

farmers might have planted a portion of their fields in high priced beets for domestic consumption. Of corn there was harvested, taking the average of the last decade, in the principal corn growing States from 50 to 70 bushels to the acre. The farmer received therefore on an average of 60 bushels to the acre at 10 cents, say $6.00 per acre all told, and from this amount he had to pay his expenses for plowing, seeding, cultivating and harvesting, his rent or interest on mortgages, taxes, living expenses, implements, etc. For beets the farmer receives $4.00 per ton on an average; in Nebraska $40 to $50 per acre, and in California $60 to $70 in the aggregate; naturally of these two amounts must be deducted the extra cost in the production, cultivation, harvesting and freight, which expense will amount to from $25 to $30, according to quantity raised and the distance to the sugar factory. Supposing the farmer does receive—as the result of failure of crops abroad—as high as 25 cents per bushel, even then the normal yield of the beet fields would bring him in two or three times as much as his corn would bring him.

According to the latest statistical estimates, the population of the United States represents 4 to 4½ per cent. of the entire population of the earth, viz: 74 of the 175 millions inhabiting the globe, while we consume 28 per cent. of the 7½ million tons of the world's sugar production. (The Statistical Abstract published by the Treasury Department gives the population of the United States June 1st, 1898, 74,389,000.) Although the greatest sugar consuming nation in the world, excepting England, we are paying a tribute of over 100,000,000 dollars annually to foreign countries, while we could and should produce all the sugar we consume. While four European countries, Germany, Austria, France and Russia boast of over 1,400 beet sugar factories, up to last season we had only a baker's dozen. We consume now 340,000 tons. (Beets 40,000.) Suppose now we produced all our own sugar, this would mean a production of 25,000,000 tons of sugar beets, giving the farmer a return of at least one hundred million dollars, and employing 3,300,000 acres of farm land and about 400,000 farm hands, besides an army of men employed in factories, machine shops, etc. And on the basis of our growing population, what will be the figures ten or twenty years hence?

By throwing a short glance at the per capita increase in sugar consumption in this country, we can easily arrive at reliable deductions. In 1830 the United States consumed approximately 20 lbs. per capita; in 1840, 25 lbs.; in 1850, 30 lbs.; in 1860, 35 lbs.; in 1870, 40 lbs.; in 1880, 45 lbs.; in 1890, 53 lbs., and in 1895, 63 lbs.

The per capita consumption in various other countries is given by the *Sugar Trade Journal*, as follows:

Per Capita Consumption of Sugar—United States and Europe.

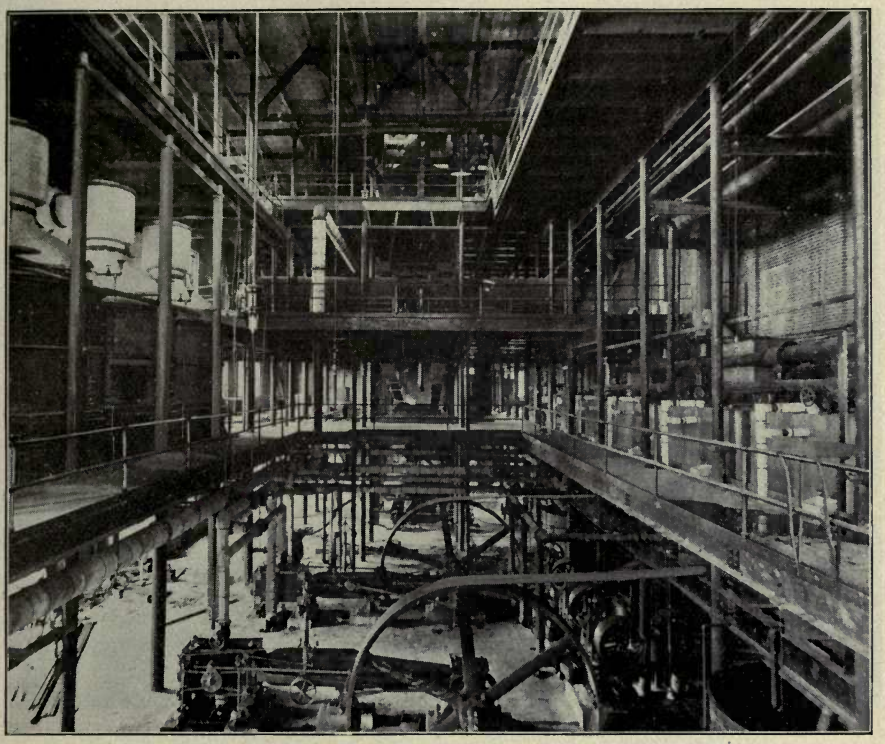
(From the Weekly Statistical Sugar Trade Journal.)

COUNTRIES.	POPULATION 1895	PER CAPITA CONSUMPTION.			
		1894-95 Lbs.	1893-94 Lbs.	1892-93 Lbs.	1891-92 Lbs.
Germany	51,650,000	26.78	26.71	22.90	23.56
Austria	43,456,000	19.81	16.57	17.20	16 05
France	38,800,000	30.61	27.80	27.86	30.46
Russia	100,239,000	10.94	11.06	10.94	10.34
Holland	4,732,000	31.30	25.55	22.90	26.88
Belgium	6,325,000	22.50	21.73	21.09	21.29
Denmark	2,300,000	45.51	42.96	43.53	43.63
Sweden and Norway	6,873,000	24 95	24.82	23.64	24.14
Italy	30,724,000	6.65	7.07	7.00	7.18
Roumania	5,800,000	4.03	4 07	4.53	3.90
Spain	17,650,000	13.68	12.47	12.38	11.06
Portugal and Madeira	5,082,000	12.92	13.09	12.51	12.43
England	38,927,000	86.09	84.78	77.40	80.73
Bulgaria	3,310,000	8.88	7.14	6 07	5.16
Greece	2,235,000	6.26	7.29	7.38	8.62
Servia	2,256,000	4.01	4.25	4.22	3.81
Turkey	21,983,000	7.65	7.25	7.64	9.30
Switzerland	2,895,000	44.66	43.20	31.62	31 30
Europe	385,177,000	25.64	23.25	22.02	22.64
United States	69,753,000	62.60	66.64	63 83	63.76
Total	454,930,000	31.07	29.33	28.20	29.00

From the above it will be seen that England is still at the head as sugar consumer, bnt it is surely only a question of a short time, when our sugar consumption will be as great and larger than England's; for the simple reason, that our population is increasing much more rapidly than that of England. Thus in the five years from 1890-95, the population of England has increased less than one million, while our population has increased nearly eight million. On the basis of the same ratio in increase, the sugar consumption in the United States ought to reach the figure of 5,000,000 tons before many years have passed. This would mean that our farmers would have to produce annually *at least 55,000,000 tons of sugar* beets, giving them at a low calculation, a return of say *222,000,000 dollars*. It would employ at least 5,500,000 acres of the best farming land and over half million men in the field. It would provide work for a vast army of skilled workingmen and ordinary laborers in the sugar factories and in the machine shops and foundries, where the machinery is built for the sugar houses. It would give work to the builder, stonemason, bricklayer, carpenter, roofer, blacksmith and tinsmith, the bellhanger and locksmith, the gasfitter, the cooper and boxmaker, the ropemaker, the saddler and the wheelwright. The transportation companies

would have tens of thousands more carloads to haul to and from factories and another army of men would be employed in coal mines, lime stone quarries, chemical and other factories. In fact there is hardly a branch of trade, that would not be benefitted directly or indirectly by this industry, which would represent modestly estimated an investment of about $550,000,000 in sugar factories alone, using at least 6,600,000 tons of coal, 4,400,000 tons of lime stone, 500,000 tons of coke, besides a vast quantity of chemicals and other material.

It is therefore no longer a question whether the sugar beet industry

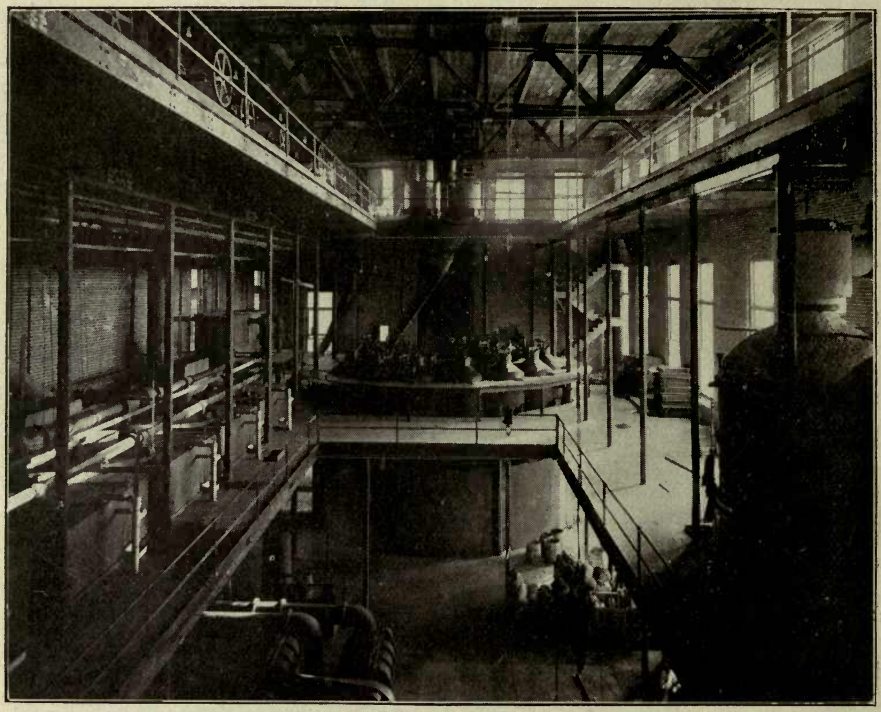


A GLIMPSE INTO THE INTERIOR OF THE ROCHESTER SUGAR HOUSE —NORTH END.

will thrive in the United States, and whether it will offer a safe and profitable investment for capital.

The brilliant results obtained by the beet sugar factories now in operation and the favorable outturn of the beet culture experiments in the majority of our states, (and in this connection the fact is to be remembered, that beet production increases steadily in quantity and quality under rational and systematic culture), makes it a safe prediction, that beet culture and the beet sugar industry in the United States, will assume enormous proportions within the next decade. We believe that

the time is not far distant, when every pound of sugar consumed in the United States will be grown and manufactured in our own country and when instead of being the largest importers of sugar we shall become an exporter of this paying staple. We believe it to be a fact that every man who takes an interest in the economic questions of the day, be he farmer, manufacturer, capitalist or statesman, has been thoroughly aroused to the importance of the subject and thus we find it agitated by our agricultural and trade journals, the daily press, state boards of trade, farmers and manufacturers associations, government and railroad officials, capita-



A GLIMPSE INTO THE INTERIOR OF THE ROCHESTER SUGAR HOUSE —SOUTH END

lists and every thinking man. It has become a burning public question. Outside of private parties, the agricultural experiment stations all over the country are experimenting on a large scale in analyzing soils and in planting and testing sugar beets. The department of agriculture has sent out tons of literature concerning beet growing, distributed thousands of tons of seed free to farmers and is doing everything in its power to foster interest in the industry. The ultimate result certainly cannot be doubtful. The unnatural hesitancy of capital to work this great and promising industrial domain properly, (it is probably the only industry of this kind at present in the United States paying in a bona fide way

25 per cent. and more net profit on capital invested), seems to be gradually disappearing. Proof thereof we find in the rapidly increasing beet acreage, the erection of new and the enlargement of the already existing beet sugar factories, and the abundance of sugar projects in many states of the union.

The capitalist and moneyed corporations, looking for a safe and profitable investment for their means, can certainly do no better than to engage in this new industry. It is the coming investment. To supply the present sugar demand we would require about 900 more factories of a daily capacity of 350 tons each, and each representing an investment of say at least $350,000. This may give an idea of the magnitude of the future of this industry. We furthermore think, that what it has taken the Old World a century to acomplish, will be accomplished here within the next decade or two, and that we shall witness in this new industry a wonderful industrial power, which will increase the welfare and prosperity of our agricultural and manufacturing population, give honest employment to thousands of people and treble and quadruple the value of our farm lands and increase the wealth of the nation at large.

The industry, as far as the supply of acreage is concerned, is firmly established. The farmers were slow to get started in the beet industry but they soon found that the *profits from raising beets were so much more than those received from growing grain or fruit, that farmers who once have gone into beet culture and are supplying the factories now in existence usually want to double and treble their acreage*, and there is a legion of farmers all over the United States anxious to plant beets. The question is now, how can such a prospective crop be handled? There is but one answer and that is: *More factories.*

To interest capital and hasten the erection of more factories the farmers can do much in the way of showing the adaptibility of their soil and climate for the production of a high quality beet.

Part II.

THE CULTURE OF THE SUGAR BEET.

GENERAL REMARKS The late U. S. Senator Leland Stanford, one of the most enthusiastic supporters of the beet sugar industry in its early stages in California, prophesied years ago, that the present generation would see the homely old beet become a king of the agricultural domain, as potent as corn or cotton ever was. "*The sugar beet is the hope of American agriculture*" he once wrote and never a truer word was spoken. Whether his prophesy shall become true rests with the American farmer and we think he may be depended upon in this respect. There is no branch of agriculture at the present day receiving so much attention from agricultural economists and progressive farmers in the United States as that of sugar beet growing. This is but natural when we consider that the *consumption of sugar is rapidly increasing* in this country and that *during the last five years it has taken three fourths and more of the money received from exported wheat and flour to pay for the sugar imported during the same period.* The sharp competition from countries having cheap lands and cheap labor has so reduced the price of wheat and other farm products, as to make it necessary to replace grain growing to a considerable extent by a more intense system of farming such as growing sugar beets for the production of sugar.

Fig. 1.
VILMORIN. LE PLUS RICHE.

Before entering into detail on the subject of beet culture, we must discuss what constitutes a good beet for sugar making purposes.

The beet—Beta vulgaris—is a plant of the order of the chenspodiaceae—goosefoot family—and has been known for centuries. The plant was found growing wild in Egypt and along the shores of the Mediterranean, and was cultivated long before the Christian Era. Many varieties were known to the ancients, of varying degree in color and quality. Other well known esculent

plants belong to the family as well as our common weeds. There are some 40 varieties of it in the United States. There are three well marked classes of beets, viz: those needed for human food; 2, those used for stock feeding, and, 3, those used for sugar making. The red and yellowish varieties grown in our gardens and fields are types of the first class; the many varieties of Mangelwurzel or stock beets, illustrate the second class, while the white Kleinwanzlebener and Vilmorin (Figs. 2 and 3) are representatives of the third class.

Fig. 2.
KLEIN WANZLEBENER.

The real sugar beet is white in color a slim cone with a single tap root covered with fine hairlike rootlets. Originally the sugar beet was identical with the ordinary field or garden beet, but by careful cultivation and selection of seed the sugar beet has been raised from its former condition until it now contains from 15 to 18 per cent. of sugar. In the development of the sugar beet the different types have been built up in the same general way by breeding and selection, as have the different breeds of cattle. The varieties of beets best known here, outside those already mentioned are the Simon Legrande, Desprez, Florimond Desprez.

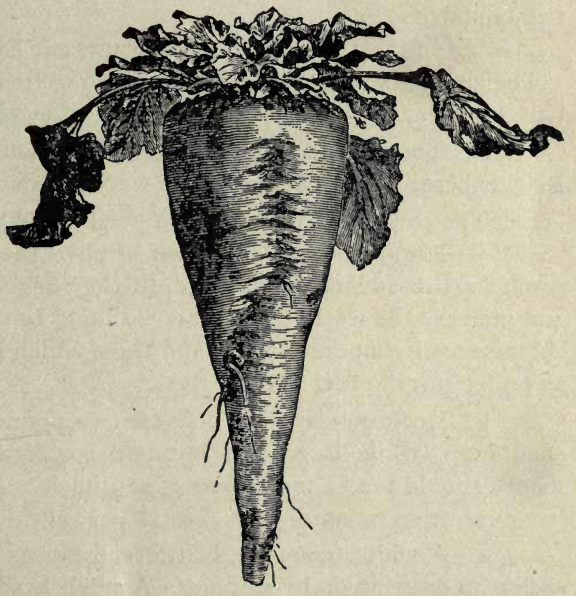


Fig. 3.
VILMORIN.

STRUCTURE OF THE BEET

Internally the beet root is built up of a large number of concentric rings formed of a much larger number of small cells, each of which is filled with a watery solution of several bodies other than sugar. A cross section of the beet is shown in Fig. 4. These bodies contain a number of crystalloid salts, such as phosphates malates, adalates of calcium and potassium, the salts of the latter being by far the most prominent. The juice also contains a large number of undesirable substances (colloid bodies) such as albuminous and pectinous compounds.

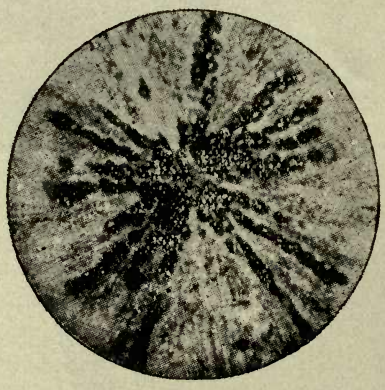


Fig. 4.

CROSS-SECTION OF A SUGAR BEET.

SIZE OF BEETS

It is well known that small beets are richer in sugar than large ones. In order to get satisfactory returns in sugar contents, it is therefore necessary in raising sugar beets to keep the size down by close planting. On the other hand it will not do to grow the beets too small, as the yield would be affected to too great an extent. The typical size is considered to be about a pound and a half to two pounds.

Brien in the "Journal des Fabricantes de Sucre," Oct. 23, 1878, says: "The size of the beet is the inverse ratio of its sugars and salts ; the content of water increases with the size and the weight of the beet."

The following is from a report by Commercial Agent Hawes, of Reichenberg, Austria-Hungary :

"The conditions required of a good sugar beet are :

"1. Regular shape (cone pear or olive shape). Many side roots or prongs are disadvantageous because they make cleaning more difficult, and increase the waste. The leaves should be thick and should be of the characteristic shape and color, and those which lie flat are to be preferred as protecting the beet against frost.

"2. Medium size, say one to two pounds. Small beets make a small crop, while large beets contain comparatively little sugar. The length should not be more than 35 centimeters (14 inches).

"3. Rich in sugar from 9 to 26 per cent.

"4. A white, compact, brittle substance. Such beets are more resistant to destruction by storage. A small head not protruding from the ground, as this head must be cut off, containing as it does very little sugar.

"It is very important to select the proper variety for a given district,

because the different economical conditions of climate and soil require different varieties, if the largest possible crop is to be harvested. It is therefore quite necessary for every farmer to experiment with different varieties."

Fig. 5.
POSITION OF BEET IN THE SOIL.

It is important not only that a sugar beet should be of the proper shape and size, but also that it should be grown in such a manner as to secure the protection of the soil for all of its parts except the neck and foliage. The proper position for a beet to occupy in the soil at the end of growth is shown in Fig 5. This position can only be secured for the beet by growing it in a soil sufficiently pervious to permit of the penetration of the tap root to a great depth. It is for this reason that subsoiling in the preparation of a field for the growth of sugar beets is of such importance. If the beet in its growth should meet a practically impervious soil at the depth of 8 or 10 inches, the tap root will be deflected from its natural course, lateral roots will be developed, the beet will become disfigured and disturbed in shape and the upper portion of it will be pushed out of the ground, as shown in Figs. 6 and 7. Experience has shown that the content of sugar in those portions of a beet which are pushed above the soil is very greatly diminished.

SOIL AND CLIMATIC CONDITIONS

The sugar beet thrives in a variety of soils, but best in rich well cultivated and well manured soil. Calciferous or clay sandy soils are equally suitable for it. A permeable subsoil is needed and wherever this does not exist a well arranged drainage system must be resorted to. A sandy loam has twofold advantages for sugar beets; firstly, as it permits the beet root to penetrate deep into the soil, and secondly, because beets that are grown in such soil are easily harvested without great loss by what is called "tare"; in other words the beet comes comparatively clean out of the ground, whereas beets grown in clay soil are very hard

to get out of the ground, involving an extra expense to the farmer, by reason of the adherence of this soil to the beet and upon which the farmer pays freight. On no account should poor land be selected for beet culture, or land that is not well drained, for although the beet requires an abundance of moisture, yet it does not thrive in wet soils.

Sufficient sub-moisture is necessary to enable the beet to mature. While in the first stages of development the plant exhausts all the surface water of the land, aided by the natural evaporation caused by the sun's rays, and as the surface grows dry, the thin tap root of the plant works down to the subsoil, where it must find sufficient moisture to fully mature the root.

If the land intended for beet growing has never been cultivated before it must be thoroughly exposed to air and light, otherwise the crop would prove a failure. On basis of scientific researches it is claimed that the production of sugar in the beet is the effect of light rather than heat, and that the main development takes place after root growth is at rest, and that progress is made more rapidly under normal heat and light conditions, where there is a maximum of soil moisture and a minimum of air moisture.

As regards soil composition the requirements are: Phosphoric acid, which increases the sugar in the beet; magnesia, lime, potash or soda and nitrogen. Of the latter little is required and a larger quantity would be rather injurious to sugar production.

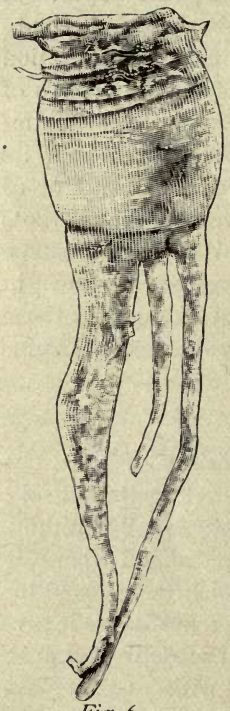


Fig. 6.
IMPROPERLY RAISED BEET.

As regards climate the sugar beet is not over particular. Like all biennial plants it can stand heat and cold; abnormal heat however, as well as abnormal cold, check its development and tend to make the plant run into seed the first year. A summer temperature of not too low a degree is required. The experience of those countries where the beet is most successfully grown shows, that the beet thrives best where an average temperature of about 70° F. for the three summer months—June, July and August—is found. In considering the availability of a certain location for beet raising, it is customary to draw a line connecting all points having this average temperature 70° F. This line is called the isotherm of 70 degrees. Lines are drawn parallel to this line, at a distance of 100 miles either side, and the belt of land included between these lines is considered to be the portion of the land where the beet is most likely to be successfully grown. The special report lately published by the United States Agricultural Department, gives a very exhaustive

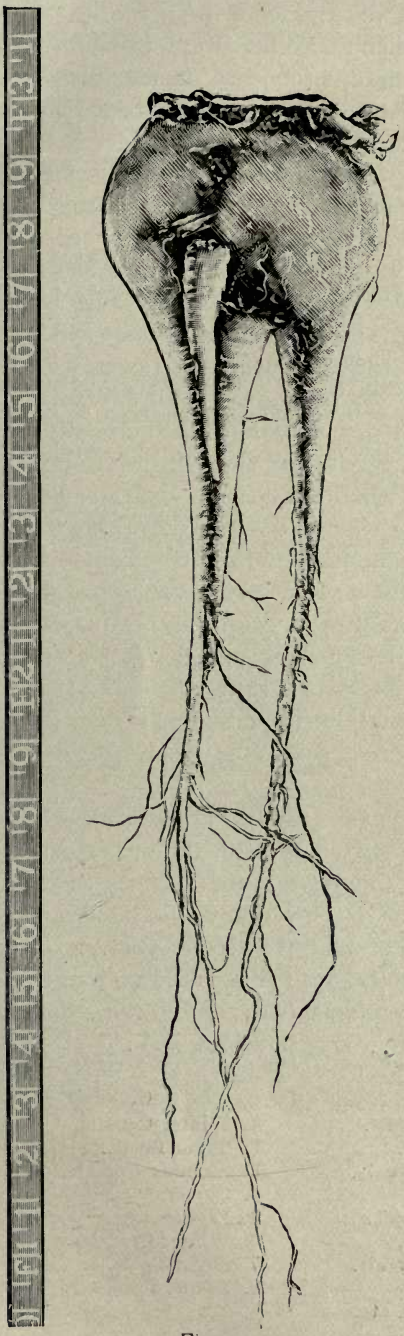


Fig. 7.

IMPROPERLY RAISED BEET.

and comprehensive explanation under the heading of "Climatology," the study of which we would recommend to the reader. This publication also gives a new map of the sugar belt with triple isothermal lines, from which the intelligent farmer can draw his own conclusions, by way of comparison with local climatic and atmospheric conditions.

Of the other climatic conditions which have an important bearing on sugar beet production, the rainfall during the crop season is of great importance. In order to produce a satisfactory crop both as regards quantity and quality, the sugar beet requires a certain amount of moisture. There should be an annual rainfall of at least 25 inches, and 30 inches would not be an excessive amount; this rainfall should not be less than two inches nor more than four inches per month. The amount of water required to mature a crop of sugar beets depends largely on the nature of the soil and the cultivation which the crop receives. Where the moisture is not derived from rainfall in the usual way it must be supplied by irrigation. If the soil is well supplied with water during the spring, thereby giving the crop a fair start, it will be able to mature even during a very dry season. A dry fall is the most favorable for proper ripening of the crop. Experience has proven that dry sunny weather during the fall is necessary for the perfection of the chemical changes wrought in the beet tissue and juice, whereby the sugar is produced.

AREA TO BE ALLOTTED TO BEET CULTURE. ROTATIVE SYSTEM

The experience in most of the German and other European beet raising districts, has demonstrated the fact that the sugar beet may be grown on any one piece of ground adapted for its culture, every three years under a rational rotative system. By a rational rotative system is meant an alternating change of crop, by which a certain preceding crop prepares the ground for a certain following crop; in other words the change of crop must not be made arbitrarily, but in regular rotation, deeprooted plants interchanging with shortrooted ones, cereals with leafed plants, and arranged in such a manner that the cereals, grasses and vegtables recuperate the soil and provide it with food necessary for the growth of the beet. In some localities of Europe beets are raised on the same piece of ground two or even more years in succession, but such culture is attended with risks and drawbacks. The farmer who wishes to remain on the safe side will not devote more than one-fifth to one-third of the acreage under cultivation to the beet, although many beet raising European countries, especially in Germany, the farmers raise beets on 40 to 50 per cent of the acreage area. In soils which have never grown beets before, as is the case with most localities in this country, they might be raised for several successive years without danger to the productiveness of the soil, nevertheless we would always favor a rational rotation.

As to the crops to be grown in rotation, the practical farmer is the best judge and will of course consider local conditions, such as marketability of the crops to be raised, etc.

A good plan of rotation which we understand is much practised by western farmers is to grow first corn, then some small grain, say wheat, oats or barley, and then sugar beets. The reason for starting the rotation with corn is, that the removal of the butts, which would be necessary if beets were grown on the same piece of land the second year, is often expensive, while at the end of the second year this would no longer be necessary. In this connection a few examples of crop rotation, such as is practiced by beet growers in Germany, may be of interest:

A.	B.	C.
1. Winter Cereals.	1. Winter Cereals.	1. Winter Cereals.
2. Sugar Beets.	2. Sugar Beets.	2. Sugar Beets.
3 Summer Cereals.	3. Summer Cereals.	3. Summer Cereals.
4. Potatoes.	4. Clover.	4. Clover.
5. Summer Cereals.	5. Winter Cereals.	5. Pasture.
6. Sugar Beets.	6. Sugar Beets.	6. Winter Cereals.
7. Summer Cereals.	7. Summer Cereals.	7. Sugar Beets.
8. Clover.	8. Potatoes.	8. Beans, Peas, etc.
9. Winter Cereals.	9. Beans, Peas, etc.	
10. Oats.		
One-fifth Sugar Beets.	Two-ninths Sugar Beets.	One-fourth Sugar Beets.
One-half Cereals.	Four-ninths Cereals.	Three-eighths Cereals.
	With heavy manuring.	

In the beet sugar districts of France a more simple rotation is generally practised by the farmers, for instance :

1. Sugar Beets.	1. Sugar Beets.	1. Sugar Beets.
2. Wheat.	2. Beans, Peas, etc.	2. Wheat.
3. Oats.	3. Wheat.	3. Potatoes.

The plan mostly adopted by the German beet growers is the socalled four field plan. From this as from every other plan, bottom lands, moory

FARMERS UNLOADING BEETS INTO THE BEET SHEDS OF THE MICHIGAN SUGAR CO'S FACTORY AT BAY CITY.

or clayey soils, not being adapted for beet culture, are excluded and must be used for other purposes. The good land is divided into four sections, which are worked on a four year turn of rotation, as follows :

1. Winter crops with 20 tons stable manure per acre.
2. Sugar beets without manure.
3. Summer crop with 12 tons stable manure per acre.
4. Clover without manure.

This plan of rotation is maintained once and for all. If desirable or convenient, each section may be subdivided into two fields, so that two kinds of winter cereals and two kinds of leafed plants may be raised.

The principle of the above four-field plan is to rotate cereals or shallow growing plants with leafed or deep growing plants, and experience has proven it to be a fact, that by carefully observing the rotation, the yield of the cereal crop is largely increased, owing in the first place to the more careful and intense cultivation of the soil, and secondly to the more extended use of stable manure and fertilizers.

Beets should always follow the cereal crop, because the latter being harvested early leaves the ground in readiness for early fall plowing necessary to successful beet culture.

FERTILIZATION

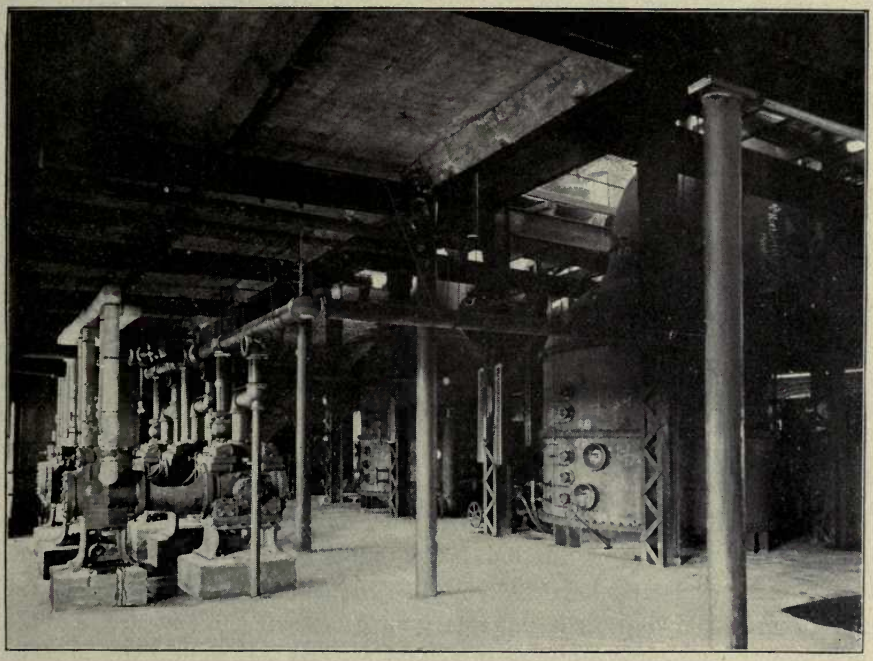
One of the great advantages most of our soils offer to the intending beet grower is their natural fertility. The German and most other European beet growers starts with a cost of from $10 to $15 per acre for fertilizers, while our farmer if he cultivates his land properly, will not have to figure on much expense in this respect. The contention however, which we find frequently expressed by farmers who have never raised any sugar beets and frequently even those who have raised beets for a season or more, viz., that just as good results can be obtained in beet raising without the use of manure and fertilizers it certainly wrong and misleading. As already stated the sugar beet requires a rich soil, which it leaves more or less exhausted. This soil must contain nitrogenic matter, potash and phosphoric acid, magnesia and lime, which constituents to some extent it receives from the previous crop, but to insure a satisfactory return, both as regards quantity and quality, the soil on which the beet is grown should receive outside of the stable manure, which should be applied latest in the fall previous to the planting an addition of fertilizers containing the aforementioned properties. It is even preferable to give the stable manure to the crop preceding the beet crop.

As stated in some of the station bulletins the above mentioned constituents are contained in a considerable degree in the leaves and crown of the beet which, when left in a field, recuperate the soil in a measure, the percentage however is not sufficient to replace the amount removed by the beet.

In Farmers' Bulletin No. 52, Dr. Wiley gives the quantities of the aforementioned constituents in 1000 pounds of beets and beet leaves, as follows:

CONSTITUENTS.	ROOTS.	LEAVES.
Potash.	3 3 pounds.	6.5 pounds.
Phosphoric Acid.	0.8 pounds.	1.3 pounds.
Magnesia.	0.5 pounds.	3.0 pounds.
Nitrogen.	1.6 pounds.	3.9 pounds.
Total ash.	7.1 pounds.	18.1 pounds.

These figures speak for themselves and show the wisdom of not removing the leaves from the fields. It stands to reason that a soil to which these constituents are not fully restored will gradually lose its faculty to produce crops of normal quantity and quality. A good soil can only be kept up to the standard by restoring to it all the crop has removed, and a poor soil naturally requires to be supplied with those elements in which it is deficient. The farmer should therefore study this question carefully. It would be difficult, not to say impossible, to lay down definite rules. The amount and nature of fertilizer to be applied much depend of course on the richness of the soil, and the experienced farmer is the best judge in this matter, and in most cases the question can only be solved satisfactorily by systematic experiments.



VACUUM PAN FLOOR—ROCHESTER FACTORY.

Sometimes results are found lacking even under a copious use of fertilizers, which then is not due to inefficiency of the fertilizing material, but rather to defective quality of the soil, when an amelioration of natural, chemical and climatic effects is more needed than fertilizing. Where this is impossible a thin coat of manure should be spread evenly over the field in fall and plowed under as soon as possible. Poor soils may be brought up to the required standard of fertility by applying the fertilizer for several years in succession. It is preferable however, to do this gradually, instead of by one heavy application, which would be apt to produce overgrown beets of impure quality, inferior for purposes of manu-

facture. *In any case the manure must be well rotted.* Under no circumstances should stable or barnyard manure be applied heavily in the spring, as this would have a tendency of producing beets of rank growth with low sugar contents and low purity. Of commercial fertilizers, nitrate of potash, nitrate of soda, muriate of potash and sulphate of potash, dissolved phosphate rock and lime, are in their nature most suitable for beet fields. It has been found by experience that these fertilizers act much better in conjunction than when used separately. The following proportions are recommended by experienced growers:

⅔ muriate of potash and ⅓ sulphate of potash.
⅔ muriate of potash and ⅓ sulphate of potash and lime.
⅓ muriate of potash and ⅔ sulphate of potash.
⅓ muriate of potash and ⅔ sulphate of potash and lime.
Sulphate of potash and lime.
Nitrate of potash and lime.

CULTIVATING THE SOIL. PLOWING.

Plowing of the beet field should be begun as early as possible in the fall, *i. e.*, as soon as the winter crop has been harvested, and the field left in furrows, so as to expose it to action of air and light, which breaks the clods and produces a clear light soil for the seed. Only shallow plowing is required in the first instance, and for the special purpose to prevent weeds from going to seed. This done, where necessary, manure should be spread and in late fall plowing the subsoil be plowed to the depth of 15 to 16 inches, or as deep as the subsoil plow may go. However, the 16 inches or rather the difference between the unplowed soil and the cultivated soil must on no account be turned up at once.

Supposing for instance there is a difference of ten inches between the maximum of plowing, as is customary for grain, viz., five inches, and the minimum of plowing required in a good worked beet field, care must be taken not to turn up at once these ten inches of unplowed soil, *i. e.*, the ground below the bottom of the uncultivated soil. In this layer, never as yet having been exposed to air and light, failure of the crops would be inevitable, not only of beets, but also of all succeeding grain crops. Many farmers in this country have paid dearly for this experience. In the first plowing not more than four to five inches of the uncultivated soil should be taken up, *i. e.*, besides the four or five inches cultivated soil at the very outside another four or five inches. It would not be advisable to increase the original four to five inches in fall plowing to more than eight to ten inches. The subsoil plow may of course go as deep as possible, *i. e.*, as deep as it can be dragged by the team.

If the plowing has not been done in the fall, it should be started as early as possible in the spring, *i. e.*, as soon as the frost is out of the ground and the ground dry enough to prevent sticking.

In following the outlined instructions the soil gets the necessary airing, and the snow and the frost of the winter, and the sun of the spring will give it the required mellowness and looseness and get it in good condition for planting the seed the latter part of April or beginning of May.

PREPARING THE SEED BED

For a perfect seed bed the soil should be worked to the depth of four or five inches, by the use of a pulverizer or cultivator, once lengthwise and once crosswise. This work must be done thoroughly, so as to loosen any weeds that may already have sprouted. Next the field is cross-harrowed once each way to level the soil perfectly and finish killing the weeds. After this with the use of a heavy roller the top soil should be smoothed and packed well (two to three inches). The killing of the weeds is absolutely necessary. If weeds are allowed to get a start the cultivation of the crop will involve much unnecessary and expensive hand work, besides affecting the result. The better the ground is packed the better the seed will sprout. Instead of a roller a plank float about eight to ten feet wide may be used. This preparation of the seed bed must be done when the ground is in good working condition and immediately before planting, say the day previous if not the same day, and for the following reasons: First, because the seed requires considerable moisture to germinate, and allowing the seed bed to dry out might be followed by serious consequences as to yield; secondly, by preparing the seed bed ahead of planting the weeds would not get a good start.

SEED

The field is now ready to receive the seed. The planting is usually done from April 15th to May 20th. But first and foremost let us say that *the success of beet culture depends mainly on securing the right kind of seed.* This is all important, and the farmer (or the factory which purchases the seed and supplies the farmer under contract) cannot be too careful in the selection of the seed.

Henry W. Diederich, U. S. Consul at Magdeburg, in a report made last fall to the State Department, sounds a timely warning, as follows:

"If I may express an opinion based on my personal observation, it is that some of our beet-growers should insist more than they have upon getting none but the very best beet seed, grown from high grade individual "mother" beets, to distribute under the beet growers. This first class seed is sold and delivered by the growers on board cars in Saxony at from 8 to 10 cents per pound, which is a moderate price, considering the fact that it takes at least four years to get it into the market.

"There is also second class seed offered for sale in this country, at from 5 to 6 cents per pound. This is commonly called the "Nachzuchtsamen," being a seed not produced from the mother beets, but from the first class seed mentioned above. This inferior grade however is not used by first class sugar men in Germany, France, Holland and Belgium, but most of it goes to Austria, Russia and the United States.

"And this is why I deem it my duty to call attention to the importance of getting only the very best of seed obtainable. In my opinion those American growers of sugar beets who buy cheap grades of seed make a great mistake. All kinds of seed have a natural tendency to degenerate. Even the first class seed mentioned above will not bring forth beets that come up to the standard of the original mother beet, but will show a loss of from one-half to one per cent. of sugar content. Now the second generation of seed will degenerate more than as much again, and lose from one per cent. to two per cent. This is a small amount when considered by itself, yet it is sufficient, not only to turn the profits of a sugar factory into a loss, but even to drive the concern to the wall."

So far most of the seed used in this country comes from Europe, principally Germany, Austria, Hungary and France, where seed growing has been going on in many families for three or four generations. They devoted themselves entirely to the culture of beet seed and the purifying of the beet race was cared for and improved upon on scientific principles in accordance with the theory of races, just like stock raising. By crossing the best varieties and repeated critical selection of mother beets a constant improvement was obtained, so that to-day the sugar content of the beet varies between 15 and 20 per cent., while formerly only 6 to 8 per cent. could be obtained. There is no doubt that the highest point in this direction has not yet been reached. There is every reason to believe that a further improvement in the sugar beet will be obtained, until the highest standard of quality is obtained.

In Utah some farms were started in 1895, by the Mormons, for the exclusive production of sugar beet seed. A second American sugar beet seed farm has been started at Los Cruces, N. M., and others will undoubtedly follow in short order. There is no reason why we should not grow our own seed, and it is to be hoped that in course of time we will become independent of Europe in this respect. For some years to come, however, we will have to rely for the supply of most of the seed on Europe. Sugar beet growing is one of the most intricate features of the industry, and it will take years of patient study and practise until we shall have established a safe and reliable seed production of our own. Until then we shall have to depend upon the old established reputable seed growers of Europe, such a Gebr. Dippe in Quedlinburg, F. Knauer in Graebers, Rabbethge & Giesecke in Kleinwanzleben, Otto Breustedt in Schladen, Vilmorin-Andrieux & Co., of Paris, and others.

In selecting the seed soil conditions should of course be taken into consideration, and it is generally only by practical experiments that one can ascertain what variety or varieties are best suited for a certain soil; hence we would advise to give all the best known varieties a trial.

PLANTING THE SEED

The planting of the seed, 20 to 25 lbs. per acre, according to soil and climatic conditions, is best done by a seed drill, handwork in planting being less reliable. With the machine drill the farmer can plant accurately and in a straight line, which is necessary in order to enable the horse-hoe to do its work without damaging the plants. It is claimed that seeds planted with the machine drill sprout earlier and develope better than those planted by hand.

The seeds should be planted in rows from 14 to 18 inches apart, not deeper than necessary for a thin covering of soil. Never try to save a few pounds of seed, for it is much easier to thin out the surplus small plants with a good stand than to replant in case of a poor stand. It is desirable when the plants come up, that they should touch each other. Should a crust be formed on the field after heavy rain one plant will help the other to break through. The width of the rows must to some extent be determined by the richness of the soil.

For the conservation of winter moisture, for seeding purposes, the implements, plow or extirpator then the harrow and roller, should fol low in spring plowing one another as soon as possible before the clod may find time to harden in the sun.

Deep planting must be avoided, especially in heavy soil, as otherwise the plants, if they come up at all, will be weak, and in case of very early planting the seed is apt to rot in the ground. As to soaking the seed and the use of the roller before and after the drilling, or both before and after, this must depend on local conditions. Regular rules cannot be set up for it, but every practical farmer will decide the question for himself. As a general rule we would not advise soaking of the seed, for if dry weather should set in immediately after planting all sprouted seeds would perish. An excess of seed will produce in a very wet spring the inconvenience that some more work will be necessary in thinning out the plants. This extra work however, and the small extra expense for seed will be amply repaid in the fall by the larger amount of beets harvested.

CULTIVATING THE BEET

The next important work of the beet farmer is hoeing and thinning out. Before plants are up many small weeds just germinating may be killed by hoeing the surface over the rows with a steel rake. The main thing is to kill all weeds as fast as they appear and to keep the ground loose. This work is best performed with a one-horse cultivator working two or

four rows at a time. If immediately after planting the seed heavy rains should form a crust on the field a light harrow may be used, but only in case the seed has not germinated, otherwise it would be better to use a cultivator, following the rows easily discernable from the marks of the presswheels. As soon as the plants break through the ground and the rows can be followed, actual cultivation must begin. It is almost impossible to cultivate and hoe too much. Frequent hoeing is one of the main causes for satisfactory and heavy yields. In Germany they say the "*sugar is hoed into the beets.*" Three hoeings are absolutely necessary and considered as sufficient, but we would strongly advise at least four to five hoeings. The additional hoeings will of course involve extra work and extra expense, but these will be amply repaid by a heavier and fuller yield of beets. Experiments in this direction have shown that the *additional hoeings increased the yield from an acre one-half to three-fourths ton and more, and produced a better quality of beets.* The reason is easily explained: Frequent hoeings keep down weeds, loosen the soil, so that the air can exert its beneficial influence and keep the moisture in the ground. Hoeing should be begun as early as possible, twice before the thinning out, which should be started as soon as the young plants have roots about one-eighth to one-sixth inch in diameter, or are about two inches in height. *Great care must be taken in attending to this part of the work, which is the most important of all the cultivating work.*

THINNING OUT

Early thinning out is the main requisite for successful beet raising, and can only be done properly by hand. The thinning out must be done in such a manner as to leave the plants standing six to eight inches apart. In very rich soil six inches and even four inches space between each beet in the row would be preferable, in fairly rich soil it would be advisable to thin out to eight inches apart, while in poor land thinning out to ten inches apart is necessary.

The rows should first be spaced or bunched, which is done with a small four-inch hoe, cutting a four-inch bunch of beets out and leaving a two-inch space, which will contain several plants, all of which are removed by hand pulling except the strongest plant. If timely thinning out is neglected the roots become entangled, making the thinning detrimental to the plant that is left. In small beet fields the thinning can generally be done by the family of the farmer, but the work must be done quickly, and where a larger acreage has to be attended to it is advisable to hire help rather than delay the work until the beets attain much size. The pulling out of the surrounding plants leave the remaining one in weak condition, which is not the case while only beginning to send its root into the ground.

After the thinning out three more hoeings, or if possible four should be given, and the beet needs no further care until the harvesting time, about five months after planting.

WIDTH OF ROWS

As to the distance from beet to beet we would recommend 18x8 inches, which would give to each beet in the aggregate 144 square inches, and which as experience has shown is the right average, guarding the interests of both—the farmer for many beets, and the factory for good beets. This space of 144 square inches for every beet ought to give the right medium weight of one and one-half to two pounds per beet by a normal growth of the field. What this medium weight means for the farmer will be seen by the following:

At 18 inches between rows, and 8 inches apart in the row, there will be 18x8 equals 144 inches apart for each plant.

One square yard equals 1296 square inches, or 144 : 1296 equals 9 beets.

If we deduct one-third for faulty seed, dying plants and for bare spots in the field, we will have at harvest time 6 beets for each square yard.

One acre contains 4,840 square yards.

6 beets per yard, at 1 lb., equal 6 lbs.
6 beets per yard, at 1½ lbs., equal 9 lbs.
6 beets per yard, at 2 lbs., equal 12 lbs.

Therefore, per acre at 6 lbs. per yard, equal 14½ tons.
9 lbs. per yard, equal 21¾ tons.
12 lbs. per yard, equal 29 tons.

TONNAGE PER ACRE

This shows that the raising of 10 to 15 tons per acre should be easily accomplished with good tillage and tollerable favorable soil and climatic conditions. The average tonnage per acre varies in different localities. At the present time, according to the reports of the Agricultural Department, the average yield is between 10 and 15 tons, although in certain localities farmers can raise a good beet with a tonnage as high as 25 tons to the acre.

The amount of sugar obtained from one ton of beets depends wholly upon the purity of the beet and its sugar content. Usually the amount ranges from 8 to 12 per cent., or from 160 to 240 pounds. Some crops in certain sections may do better, but the forementioned per centage is a fair estimate of the average.

We may here refute a prejudice often found among farmers, who have never before raised sugar beets. They have probably heard about the so-called "beet weariness" of beet fields in Germany and fear the same condition may make themselves felt in this country in time to come. There is absolutely nothing in this. In the first place, no such conditions are known any more in Germany since fertilizers like Guano, Potassium, Super Phosphates, etc., are used. This subject requires no consideration where only a reasonable percentage of the areable land is used for best culture. To the contrary, *the longer a field will be under rational beet culture the larger must be the crops, not only in the beets, but also in the grain following them.* This has been found correct in Europe during fifty years of observation, and same conditions will result in this country. We have already proof thereof in those states of the Union,

where the beet sugar industry has already been firmly established. We may refer in this connection to: "Transactions of the California State Agricultural Board for 1895," Sacramento, A. J. Johnston, Superintendent on Printing 1896. (Chapter on beets). "This report shows plainly that, and to what extent the yields have increased on the beet farms in California since 1890, and that there is near every factory a zone in a radius of about 10 miles, where the land adapted for best culture has increased five and eight fold, from $30 to $100 and $250 per acre. These figures speak plainly for the introduction of the beet culture in all parts of this country where at least 10 tons per acre of *good beets* for sugar manufacturing purposes may be raised.

MATURING OF THE BEET. HARVESTING

The harvesting of beets before the middle of October should only be carried on to the extent necessary to satisfy immediate factory requirements. The time of our Indian summer is the main period of the formation of the sugar in the beet. The beet does not grow larger, but its weight and purity co-efficient materially increases. Climatic conditions in the various states of course will have to be considered, but *it should be made a fixed rule to harvest only fully ripened beets.*

Cases on record in Europe show, that factories have lost as much as $15,000 to $20,000 in one campaign of 50,000 tons of beets by harvesting too early, i. e. at a time when but a small portion of the beets were fully matured. Beets taken from the same field later in the season showed a considerable increase in sugar contents and kept well in the Silos, while those harvesting before maturity very soon began to rot. The advice not to start harvesting before the crop is ripe, can therefore not be repeated too often. *A few warm days and cool nights may sometime bring the beet to complete maturity and give it its full value.* A sure sign of the ripeness of the beet easily discerned by the experienced eye, is the change of the dark green color of the beet fields into a light yellowish green. All the large outside leaves will be found to have withered away, leaving only the "heart" with its yellowish green leaves to stand. Of course it is only by chemical analysis, that the ripeness of the beet can be accurately established and the beets should not be considered fully matured, until the sugar content is found to increase no more.

The sugar factory to which the farmer is under contract, or the Agricultural Experiment Station of the state in which the beets are raised, will make such tests free of charge to the beet grower. It is advisable to harvest the riper stands in the beet fields first and leave the greener stands until later, perhaps as late as November. In as much as beets are not injured even by quite a severe frost, part of the crop may be left in the ground in an ordinary year until the end of November and even into December. The harvesting is done by means of a horse puller, which loosens the beet, but leaves them in the ground. The beets are then easily lifted

out of the ground by means of their leaves. This work is mostly done by hand as also the topping, which is the next operation in order. We would not advise to plow out the beets with an ordinary plow, as by its use a considerable loss results from breaking off the lower portion of the root and often beets are missed.

TOPPING After the beet has loosened by the puller and partially lifted out of the ground the topper grasps it by the leaves and lifts it with his left hand from the ground, while with his right hand

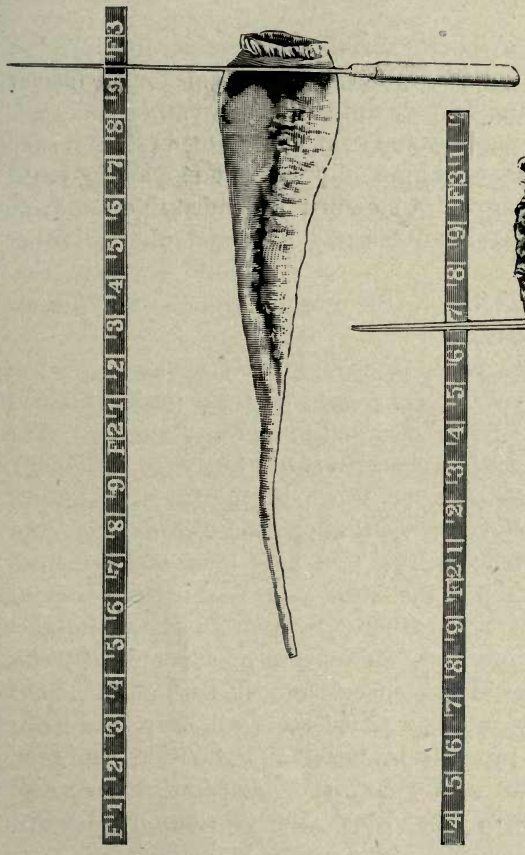


Fig. 8.
PROPERLY CAPPED BEET.

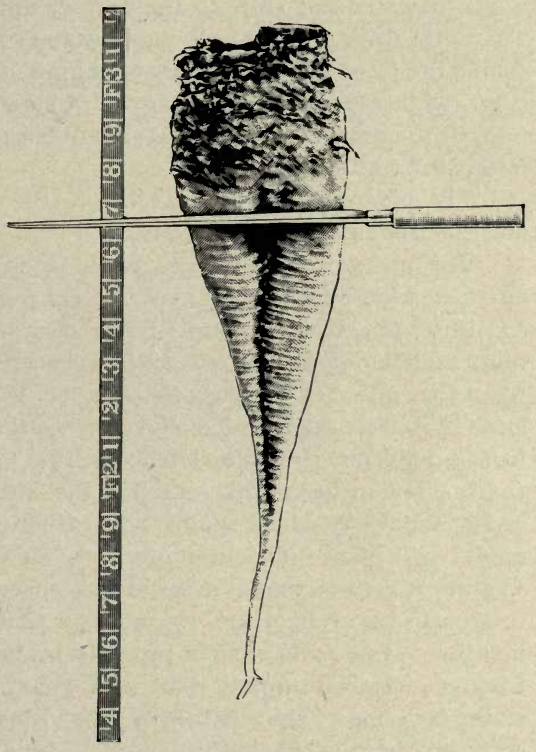


Fig. 9.
IMPROPERLY CAPPED BEET.

he removes the crown or top of the beet by one blow, cutting just at the base of the bottom leaf. (See Figure 8.) This is done by a knife made expressly for this purpose, but a strong, well riveted butcher knife with a 10 inch blade will perform the work as well. Figure 9 shows very strikingly the loss, resulting from topping an improperly raised beet. All that part which grew above the ground must be removed, if the beet

is intended for factory purposes, for the reason that the objectionable mineral salts, absorbed by the beet in its growth, accumulate in the top, particularly in that portion grown above the surface. These salts exercise a very deleterious influence on the crystallization of the sugar, hence must not be allowed to enter the factory. Where beets are used for stock feeding, only the top need be removed.

Unless the beets are intended to be preserved for sugar making during the winter months or for the production of seed, they are simply put into piles and the tops thrown over them, as a protection from the sun or frost.

PITTING—SILOING.

As beets shrink considerable, if shipped in warm weather, it is advisable for the farmer to pit them and not ship to the factory until the the weather gets cool. The extra work will be well paid by the gain in weight, besides it will enable the farmer to harvest his crop gradually without employing extra labor, while otherwise when a car of beets must be loaded in one day to prevent too great a shrinkage, it requires extra help and often all other farm work has to be neglected.

The pitting must be done before the ground freezes and all beets must be free from frost when pitted.

The pits are usually arranged in a straight row about thirty feet apart, in which not less than two tons of topped beets are placed, making a slanting pile, while the roots lying towards the center of the pit. The beets should not be covered too deeply with earth, not over six inches, when first pitted, for if they become too warm in the pit, they rapidly loose in sugar content. To allow for ventilation, two top openings, one foot in diameter, should be left in each pit. A light layer of loose straw (with a few inches of dirt on top of the straw to prevent it from blowing away) should be added before the weather gets cold, and in an ordinary season will offer sufficient protection, but in case of exceptionally cold weather it may be found necessary to cover the pits with long manure to prevent heavy freezing. If properly pitted beets will keep four to six months. If the pits are not properly protected and the beets kept from freezing, they will rapidly spoil with changes in temperature. As soon as the covering of the silo freezes two inches, shut ventilation holes with earth and keep them shut.

COST OF GROWING BEETS.

It will readily be understood that the cost per acre of growing sugar beets will vary in different localities and to quite a considerable extent. The season, the kind of soil and the skill of the grower and the choice of the seed, are factors of prime importance. Seed siuted for one locality would not suit for another.

Then the cost will depend on the price of labor, rent of land and

cost of fertilizer the acreage planted and the kind of implements used. Those who have grown beets, using only ordinary farm implements for seeding, cultivation and harvesting, state that the cost per acre is between $20.00 and $30.00 With improved machinery, such as a beet-drill, planting four rows at once, a cultivator that will remove the weeds and do all other work required by it on the same number of rows for each trip across the field and a harvester that will dig the beets by horsepower, the cost per acre would be of course materially lessened.

As an instance of what profits farmers can make by beet growing, we quote the experience of H. C. Graves & Sons, reported in an Omaha paper. They planted over forty acres of sugar beets at Council Bluffs, which were shipped by rail to the Oxnard factory, at Norfolk, Nebr., at a cost of $896.71. The total cost of this crop laid down in Norfolk was $2,196.71. Their gross receipts amounted to $3,524.17, leaving a net profit of $1,327.46, or $31.98 per acre. The loss through shrinkage while the beets were in transit amounted to $171.82. Had the beets been grown in Norfolk this sum, as well as the $896.71 of freight, would have been saved and the net profits would have been $2,495.99, or at the rate of $57.73 per acre.

Part III.

THE MANUFACTURE OF BEET SUGAR.

GENERAL REMARKS In the manufacture of sugar field work and factory work are closely interwoven and yet each has its distinctive sphere. Practically, the manufacture of sugar is accomplished by field work, while the work of the factory limits itself to the extraction of the sugar. In other words, the sugar in the beet is formed and accumulated on the field and this accumulated sugar is extracted and formed into marketable shape by the factory.

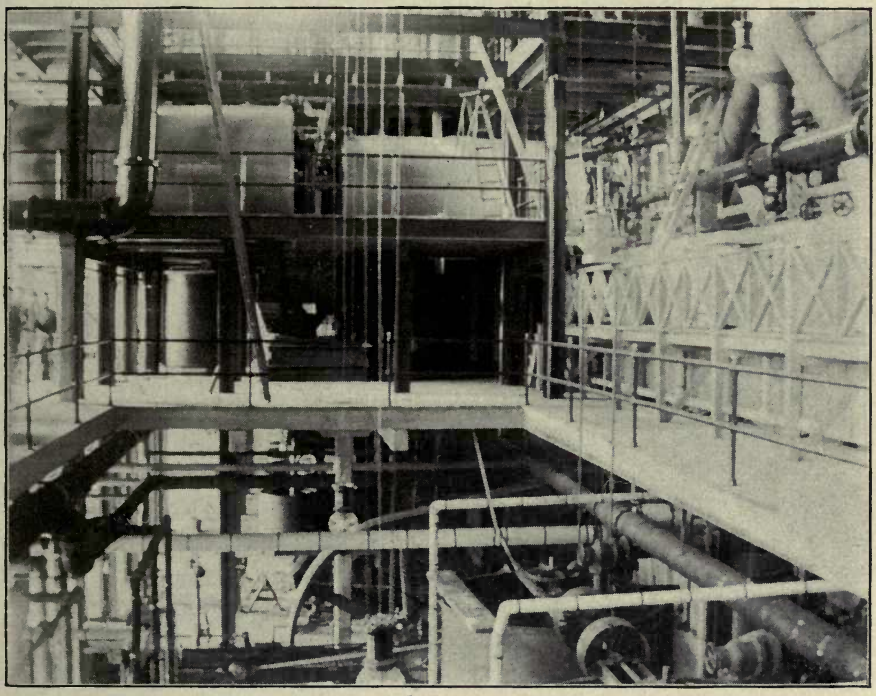
The manufacture of sugar consequently may be divided into two distinct departments, viz: the production of the sugar by the field and its extraction and reduction to a marketable form by the factory. These two principal divisions, constituting the entire process of the manufacture of sugar must complement each other; in fact successful sugar manu facture is inconceivable, where field work and factory work do not go hand in hand. Furthermore in both departments satisfactory results can only be achieved by employing the most up-to-date improved methods and machinery and above all competent and expert management.

FACTORY REQUIREMENTS The sound basis for a good paying beet sugar factory is very simple and stated in a few words : A sufficiently large quantity of beets of the possible highest quality and purity to suit the capacity of the factory, an abundant supply of pure water; adequate supply of fuels (coal, coke, etc.); supply of limestone of suitable quality; labor at reasonable figures; good transportation facilities; a market in which to dispose of the product of the factory and its by-products, and last but not not least, ample capital.

The very first and most serious consideration in starting a beet sugar plant must be given to the selection of a site, for, while the condition for beet sugar raising might be entirely satisfactory in a certain locality, they might not be favorable for operating a factory.

FACTORY SITE

The site must be selected with a view to satisfying in the greatest possible measure, the necessary requirements for the successful operation of a factory as stated above. There is more than one case on record where poor or hasty judgment in the selection of the site, not only greatly diminished the profits of a factory, but caused its utter collapse. If possible the factory should be so located, that it could draw its beet supply from within a radius of say not more than six miles, so that the beets could be delivered by wagon.



A GLIMPSE INTO THE INTERIOR OF THE BAY CITY FACTORY.

BEET SUPPLY

The first necessity of a beet sugar factory is that it should have a sure supply of good beets. In order to facilitate the supplying of the factory with such beets the plant should be located as nearly as possible in the center of a beet growing district. The further the factory is away from the beetfields the less advantageous. Not only will the profit of the farmer be lessened by reason of his having to pay freight to the railroad company for transporting his beets to the factory, but there is also the additional expense of extra handling and the loss in weight, necessarily resulting by shrink-

age during transit. It has been variously estimated that the shrinkage amounts to about 20 per cent of the original weight in seven days. This means that if a farmer, for instance, got twenty tons of beets from an acre, and it took him seven days to deliver to the factory, he would lose one-fifth of his crop in weight, i. e., he would get paid for only sixteen tons. Of course the percentage of sugar would be higher, but the tonnage less. It is also claimed that the factory cannot obtain as good results from beets grown at a distance, as from those grown near by and delivered by wagon right after having been harvested. As we have shown already in a previous chapter under fairly favorable conditions as to soil and climate and with intelligent field work, fifteen and even twenty tons of beets per acre ought to be produeed, but in calculating for the beet supply, it would be safer to figure on an average of not more than twelve tons, especially the first year, when probably many of the farmers are not as yet fully educated up to the niceties of beet culture. To supply a 350 ton plant it would require therefore, say 3600 acres to be planted in beets every year and on the three year rotation plan about 10,800 acres would be necessary as beet area.

QUALITY REQUIREMENTS

The minimum percentage of sugar required in a beet and below which factories, as a rule, decline to accept beets is 12 per cent, although they might be worked to a profit perhaps as low as 11 per cent, provided they ran over 80 per cent in purity. The sugar content and purity are the factors which determine the quality of the beet.

A high purity co-efficient will impress the practical sugar man by far more than high polarization, for the purity co-efficient is the real deciding factor for the value of the beet for the factory, inasmuch as low purity means loss of sugar in manufacture. The following, taken from Bulletin No. 64 of the Wisconsin University Experimental Station, by Prof. W. A. Henry, may be of interest in this connection :

"The problem of the relative value to the sugar manufacturer of beets of different purities is not easily solved, and concerning which there is a great diversity of opinion among expert sugar makers. The nearest approach to a correct expression of this relation may be found in the quantities of sugar available for sugar manufacture in the different cases. To illustrate, if a quantity of beets test 12 per cent of sugar, with a purity of 80 per cent, 100 pounds of these beets will contain 12x80—9.6 pounds of pure crystalizable sugar, which might therefore, under ideal conditions, be recovered as first sugar and in low grade products. In the same manner 100 pounds of 13 per cent beets with a purity of 75 per cent would furnish 13x75—9.75 pounds available sugar, that is slightly more than beets of the former quality. According to practical factory experience 12 per cent beets of 80 per cent purity will give the same amount of sugar per ton of beets as 13 per cent beets of 75 per cent purity, viz : about 160 pounds, but the former kind of beets are preferable for the reason, that the cost of extracting the sugar is increased in case of beets of a low purity."

PURITY CO-EFFICIENT

By the co-efficient of purity is meant the per cent of solid matter in the juice, in the form of sugar. A purity co-efficient of 85 means, that 85 per cent of the solid matter in the juice is sugar.

A low purity co-efficient is due to the presence of a large amount of solids, not sugar in the juice. A beet testing 15 per cent sugar with a purity co-efficient of 85 contains 17.65 per cent of solid matter in the juice. 15 of the 17.65 parts, or approximately 85 per cent is sugar. Professor W. A. Henry of the Wisconsin University Station gives the following lucid explanation in Bulletin No. 55:

"* * * In the pages which follow we speak of the per cent of sugar in the juice and the co-efficient of purity. Let us understand the meaning of these terms. A hundred pounds of sugar beets contain about ninety-five pounds of juice. This juice not only contains sugar, but various other substances, largely mineral matter, which are a great hindrance, causing serious losses of sugar during the manufacture. A hundred pounds of average beet juice will carry about fifteen pounds of solid matter, of which twelve pounds may be sugar, and three pounds matter not sugar. If we divide the number of pounds of sugar (12), by the total pounds of solid matter (15), we get 80, which sum is called the co-efficient of purity; that is beet juice with 15 parts solids, 12 of which are sugar, is said to have co-efficient of purity of 80. If the sample of juice, contains 16 parts solid matter and 12 parts sugar as before, then the co-efficient of purity is only 75. When reducing the beet juice to make sugar, each pound of foreign matter, not sugar, keeps at least one pound of sugar from crystalizing. This true, we see at once, that the manufacturer desires beet roots not only carrying much sugar, but also with a high co-efficient of purity. Immature beets, those grown on soils rich in vegetable matter or fertilized with fresh barnyard manure, those grown on land recently cleared from forest, or on drained swamp lands, are all liable to carry a great deal of solid matter not sugar in the juice, and consequently are quite unsatisfactory to the sugar manufacturer. Large beets are likewise poor in sugar. The leaf stems of the beet, as well as the crown of the beet root itself also carry much foreign matter."

WATER SUPPLY

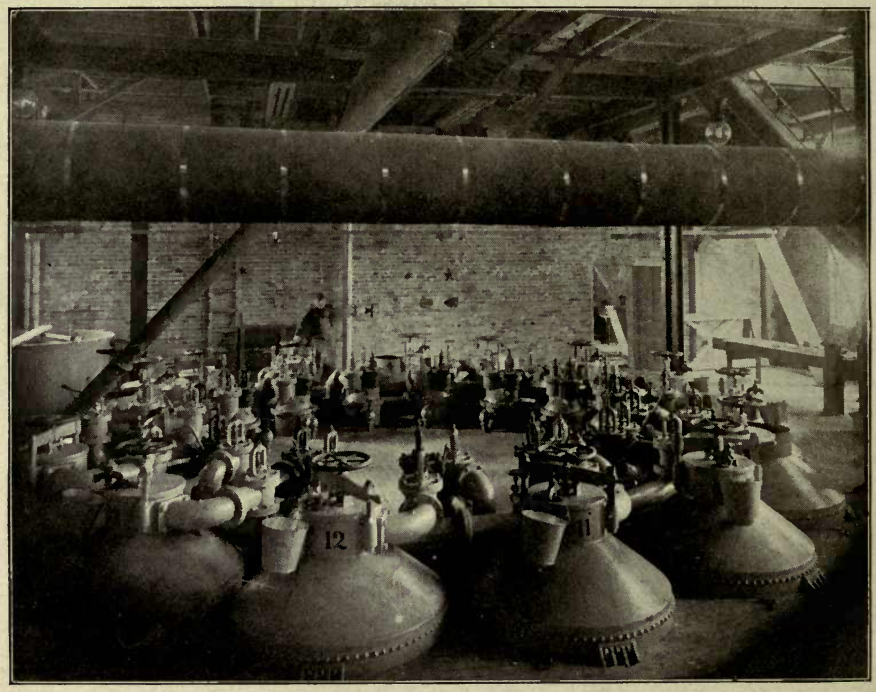
As the consumption of water in a sugar factory is enormous,—(a 350 ton plant, for instance, would require not less than 2,000,000 gallons per day for steam purposes, diffusion process, transporting beets from sheds to factory, praying the sugar, and other operations)—an abundant supply of pure water, not alkaline, must be obtainable on or near the site selected. For this reason and furthermore with a view to the cheapest and most convenient disposition of the water consumed—(perfect drainage is absolutely necessary)—location on a river or creek is preferable. The water course from which the factory is to receive its daily supply should at any rate not be more

distant from the factory than a quarter of a mile, so that the conducting channel or conduit pipes will not require too large an investment.

In this connection the following extracts from "A Hand-book for Chemists of Beet Sugar Houses and Seed Culture Farms," by Guilford L. Spencer, B. Sc., of the U. S. Dept. of Agriculture, will prove interesting:

"Salts in solution and their effect in Water used in Sugar Manufacture. The condensation water from the multiple effects, vacuum pans, etc. form an abundant and very satisfactory supply of water for the boilers.

The water for the diffusion battery should be as pure as possible and should contain a minimum amount of calcium and magnesium salts and



MICHIGAN SUGAR COMPANY'S FACTORY, BAY CITY, MICHIGAN.
DIFFUSION BATTERY.

of the salts mentioned below as melassigenic. The calcium and magnesium salts, notably the bicarbonates and the sulphate of calcium, foul the heating surface of the battery and evaporating apparatus. The bicarbonates decompose to some extent in the diffusers and deposit the normal carbonates upon the cossettes and probably influence the diffusion unfavorably. The water should not contain more than ten parts per 100,000 of calcium sulphate, otherwise incrustation may form at some stage of the concentration of the liquors.

Pure water should also be used in slacking the lime, though for economy of sugar and in the evaporation certain wash waters containing sugar, etc., are used for this purpose.

The most important melassigenic salts are sulphates, alkaline carbonates and nitrates. The chlorides are rather indifferent as regards the formation of molasses."

Under the heading "Melassigenic Salts" Mr. Spencer says:

"The following salts are positive molasses makers, that is, salts which promote the formation of molasses: Carbonate acetate, butyrate and citrate of potassium.

The following have no influence on the formation of molasses and are classified as indifferent: Sulphate, nitrate and chloride of potassium, carbonade and chloride of sodium, calcium hydrade, valerate, oxalate and succinate of potassium and oxalate, citrate and aspartate of sodium.

The negative molasses makers, that is, salts which promote the crystallization of succrose, are sulphate, nitrate,, acetate, butyrate, valerate and succinate of sodium, sulphate, chloride and bitrate of magnesium, the chloride and nitrate of calcim and the aspartate of pottassium."

FUEL, COAL, COKES, ETC.

Fuel represents another important item, to be carefully considered in establishing and selecting the location of a beet sugar factory. For each ton of beets about 13 to 15 per cent. of coal and 1½ to 2 per cent. of coke is required, the latter for burning the lime stone and for producing carbonic acid gas,—(which is obtained by combustion of coke and charcoal in ovens specially prepared for this purpose),—and the former to produce steam power. A factory working up 500 tons of beets, for instance, would consume about 75 tons of coal and 7½ to 10 tons of coke every 24 hours. Fuel as will be seen is one of the chief factors of the cost of production. In some localities crude petroleum is used for fuel. It is said to be well adapted to the factory work, cause less dirt and require less labor to handle it, thus making up largely for what it lacks in cheapness. The coke should be 72 hour coke, practically free from moisture and should contain about 92 per cent. of carbon and not more than ¾ to 1 per cent. of Sulphur.

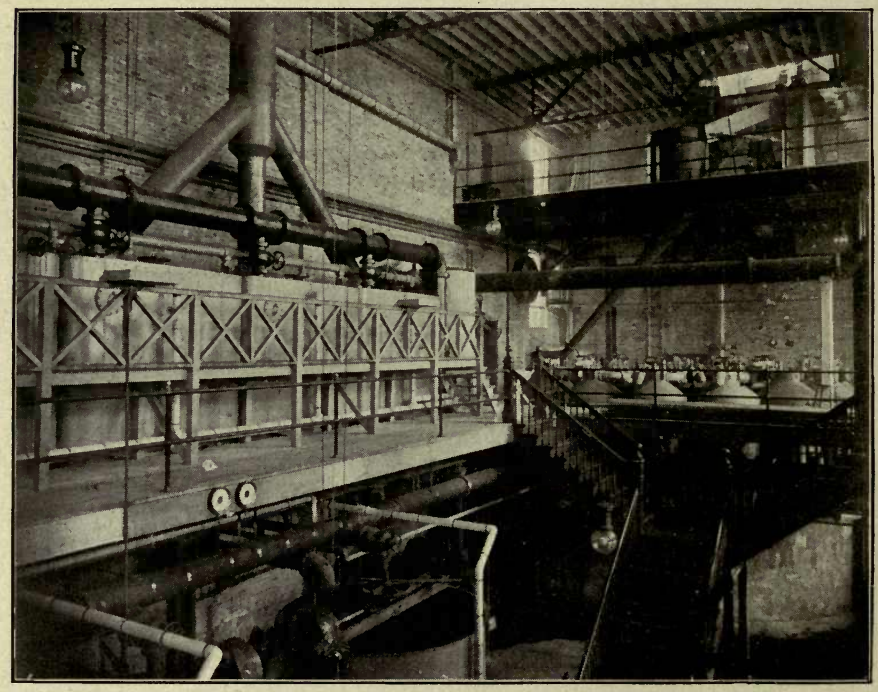
The consumption of coal depends on the one hand upon the perfect construction of the boiler plant, and on the other hand upon the complete utilization of the steam, as well as upon the most economical accumulation and utilization of all calory derived from the vapors of the boiling beet juices. In well equipped German and Austrian factories the consumption of coal amounts to from 7 to 12 per cent.

In reviewing this subject "La Sucrerie Indigéne," the leading paper of the industry in France in its issue of March 16, '97, had the following:

"The most significant fact is presented by the figure of steam for 100 kilos of beets being not over 62 per cent, which means 62 steam per 100 pounds or kilos of

beets, corresponding with 70 kilos with our regular quality of French coal per ton of beets. The factory Ouval, Bohemia shows a figure in fuel below 70 kilos and in locations where coal is cheap, the manufacturers do not hesitate for a moment in investing the needed money, sometimes in very large amounts, in improvements with regard to fuel percentage. What are the French manufacturers doing in regard to coal consumption in sugar factories? About nothing. They consume 140 kilos per ton of beets or double the amount used in Austrian factories."

Here is an object lesson for our factories, who in some instances have used not 7, nor 14, but 23 per cent. In other words, 460 pounds or 230 kilos per ton of beets.



MICHIGAN SUGAR COMPANY'S FACTORY—CARBONATING TANKS AND DIFFUSION BATTERY.

Since prices of coal and cokes vary considerably in different locations, the necessity of thoroughly looking into this question of fuel supply will be readily understood.

LIMESTONE

A ready supply of the right quality of limestone at a reasonable price, of which the sugar factories need large quantities, is the next point to be considered in studying the conditions of a locality with a view of erecting a factory. It is absolutely necessary that this limestone should be pure and free from any elements hurtful or hindering in the manufacture of sugar.

G. L. Spencer, the before cited authority, offers the following "Suggestions on the Desirable and Undesirable Composition of Limestone Used in Sugar Manufacture:"

The difficulties usually encountered in the management of the lime kiln are as follows: A limestone containing too much silica will show a tendency to fuse, and if overheated will adhere firmly to the walls of the kiln. Stone in too small pieces, or stone and coke not properly distributed, or stone with an excess of coke will sometimes "scaffold" or bridge. The above conditions soon prevent the downward progress of the stone and lime. These difficulties are obviated by the use of suitable stone, properly mixed with the coke and evenly distributed in the kiln, and by the withdrawal of lime at regular intervals. Should the charge "scaffold" in the kiln, it can only be broken down by the withdrawal of a considerable quantity of material at the lime doors and energetic use of an iron bar at the "peep-holes." The use of too little coke or the too rapid withdrawal of lime results in an undue proportion of underburned or raw lime. The admission of too little air to the kiln results in an imperfect combustion and an excess of carbonic oxide in the gas. This carbonic oxide not only is a loss of carbon, but if carelessly inhaled by the workmen, may result in serious poisoning. The addition of too much air dilutes the gas. This latter may result from leakage in the pipes, careless charging or from driving the gas pump too fast. The following table contains valuable information relative to the quality of the limestone :

Analysis of Limestones and Comments on their Composition.

(By Gallois and Dupont, Paris.)

SUBSTANCE	1	2	3	4	5	6	7	8	9	10
	%	%	%	%	%	%	%	%	%	%
Moisture	4.10	5.10	7.25	4.15	4.17	6.25	5.16	0.52	1.21	0.11
Sand, Clay and Insoluble Matter	4.50	5.15	4.90	2.15	3.07	3.17	2.25	2.85	.55	.27
Organic Matter	1.20	1.17	1.37	1.05	.97	1.12	.86	.30	.41	.15
Soluble Silica	2.10	1.75	3.30	1.05	.98	.64	.56	.06	.20	.03
Oxides of Iron and Alumina (Fe_2O_3 Al_2O_3)	.37	.41	.27	.17	.19	.15	.20	.32	.23	.....
Carbonate of Calcium (Ca, CO_3)	85.86	85.12	81.67	90.13	88.65	87.93	90.03	93.80	96.58	99.10
Carbonate of Magnesium (Mg, CO_3)	.95	.47	.59	.75	.95	.50	.45	1.81	.50	.....
Sodium of Potassium (Na_2O, K_2O)	.05	.06	.....	.10	.01	.....	.....	.....	.....	.....
Undetermined	.87	.77	67	.45	1.00	.24	.39	.34	.32	.34
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Nos. 1, 2, 3 and 4 are bad, Nos. 5, 6 and 7 are passable, and Nos. 8, 9 and 10 are excellent. Limestone No. 3 was used in a sugar house and caused much trouble notably "scaffolding," difficulty in the mechanical filtration, incrustations in the triple effect and on the vacuum pan coils. No. 9 was substituted for this stone and these difficulties disappeared.

In the examination of a limestone its physical condition as well as as its chemical composition must be taken into account. The stone should be compact and hard, thus reducing the quantity of fragments and the risk of "scaffoldiug" in the kiln.

Excessive moisture, 5% or more, in the stone reduces the temperature of a kiln when charging, involving an imperfect combustion and the production of carbonic oxide (C O); further, such stones break into small pieces under the influence of the heat. A small proportion of water, approximately 1%, probably facilitates the decomposition of the stone, and is advantageous.

Magnesium is not objectionable, so far as the operation of the kiln is concerned except in the presence of silicates, but it introduces difficulties in the purification of the juice and forms incrustations on the heating surfaces of the evaporating apparatus. It forms fusible silicates at high temperatures and thus increases the tendency to "scaffolding." The objections to the sulphate of calcium are practically the same as to magnesium.

The objections to the presence of silicates are, as indicated above, in the formation of fusible silicates of lime and magnesium. Part of the silica passes into the juice of the lime, retards the filtration with the presses, and coats the cloth of mechanical filters, to their detriment. Silica also forms part of the scale on the heating surface. Less harm results from this substance in hard limestones than from that in soft stones; hence if the stone be hard and compact, a larger content of silica is admissible, than in soft stone.

When necessarily using stone of comparatively poor quality, the best obtainable coke should be used.

LABOR

Frequently a very serious problem is presented in the labor question. The field work, i. e. the cultivation of the beet fields requires a large amount of hand labor and during a few weeks each summer extra hands are needed for weeding, hoeing and thinning the crop; then again extra help is needed for the harvesting of the crop in the fall of the year. The factory on the other hand requires outside of the skilled labor, many common laborers, employed during the campaign, hence if possible the enterprise should not be started far from cities or towns of a floating population where labor can be supplied at short notice and reasonable cost.

TRANSPORTATION FACILITIES

A very important consideration in the selection of a site for a sugar factory are the transportation facilities. There is considerable freight traffic connected with the sugar factory. Not to speak of the hundreds of carloads of building materials, machinery, etc., that must be brought to the site for the erection of the factory, there is a steady traffic in bringing supplies, such as beets, coal, limestone, coke, etc., sometimes from distant points, to the factory and in taking out the finished product and the by-products. Then again the transportation facilities are often needed to bring the workers in and around the factory to and from their homes. Most of the traffic is concentrated into the brief period of the campaign, hence ample railway or water transportation facilities are absolutely necessary.

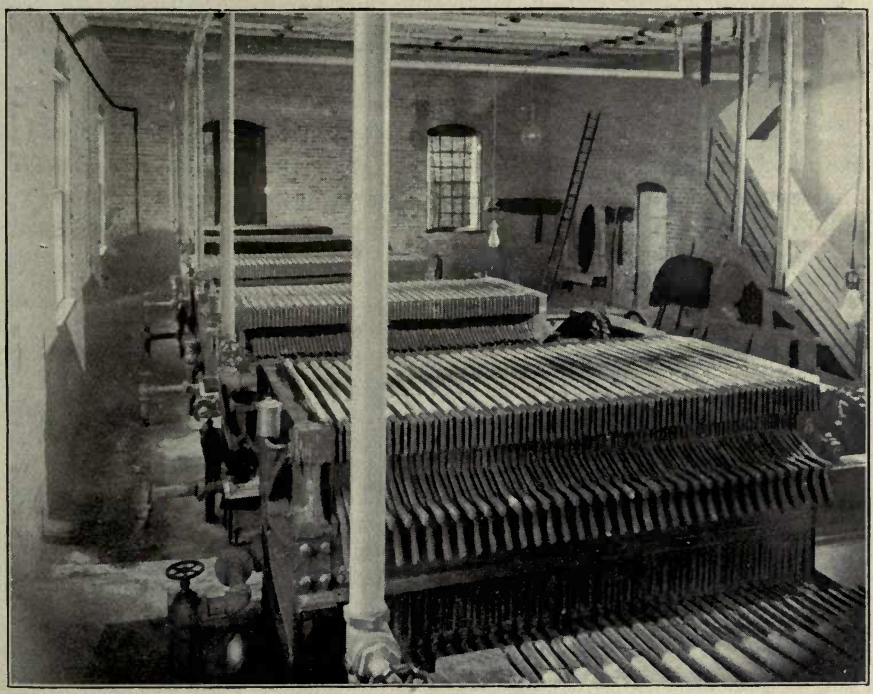
MARKET FACILITIES

A ready market in close proximity to the factory is perhaps not one of the least important conditions for success. The accessibility to trade centers, availability of transportation by water, as well as a larger number of railroads, thus insuring cheap freight and greater facilities for marketing the product quickly, also the question as to whether these facilities are

sufficient to permit of competition with other localities, perhaps more favored in this regard, are points which must be given very serious thought before deciding on a location.

THE FACTORY AND ITS INTERNAL ARRANGEMENT

The site for a factory having been selected with proper regard to the various conditions just discussed, the constructing engineer can arrange his plans in such a manner, so as to attain the most satisfactory results in the most economical way, compatible with safety. Of course it will be readily understood, that it is altogether impossible to work all plans after one



MICHIGAN SUGAR COMPANY'S FACTORY, BAY CITY, MICHIGAN.
FILTER PRESSES.

pattern. What might suit one locality, might be utterly unsuitable for another, and what would be a cheap plan for one locality might turn out an expensive one for another.

A modern sugar factory must be so arranged and equipped as to make it possible under expert and intelligent management to extract at the lowest cost of production, all the sugar contained in the beet and to convert it into marketable form. This can only be done by machinery and apparatus of the most approved and modern type and making use of every device whereby labor may be saved. In designing, erecting and

instaling sugar factories, the aim of The Fred W. Wolf Company is always, to double and treble results by introducing the most modern and improved apparatuses and mechanical appliances, whereby the labor of many hands can be saved and the process of manufacture simplified and shortened and the cost of production lessened.

A sugar factory may be said to be divided into two main departments, viz: The Beet Department and the Sugar Department. The former is subdivided again in the following stations:

1—Wash Station, where the beets are cleaned.

2—Juice Station, where the raw juice is extracted from the beets and purified, taking in Diffusion, Carbonation and Filtration.

3—Evaporating Station, where the juice is condensed.

The Sugar Department may be divided as follows;

1—Station where the juice is turned into white sugar.

2—Station where the product is gotten ready for the market.

The afore mentioned stations and departments are housed in one main building, which has a number of annexes, such as a boiler house, lime-kiln, oil house, cooperage, beetsheds, sugar storage house and office building. Sometimes one or the other of these annexes is included in the main building.

The internal arrangement of an up-to-date sugar plant is as follows:

GROUND FLOOR.	SECOND FLOOR.
Washer.	Beet Elevator.
Beet Elevator.	Diffusion Battery.
Pulp Pit Under Diffusion Battery.	Carbonation Tanks.
Engines & Dynamos.	Quadruple Effect (Evaporators.)
Pumps.	White Sugar Mixer.
Centrifugals.	Granulator.
Sugar Melter.	Sugar Elevator.
Sugar Elevator.	Dustroom.
Machine Shop.	Labratories.
Office.	

THIRD FLOOR.	FOURTH FLOOR.	FIFTH FLOOR.
Crystalizers.	Beet Elevator.	Sulphutation Tanks.
Pulp Presses.	Automatic Scale.	Condensers.
	Slicer.	
	Filter Presses.	
	Vacuum Pans.	
	Mechanical Filters.	

In the foregoing plan we have not considered installations necessary to diminish the loss which occurs, owing to the inability to extract all crystalizable sugar from the residue molasses, forming from 16 to 25 per cent. of the boiled syrup.

There are various methods, such as the Osmose process, the Steffen, the Ranson process, and the Strontian process, and others, by which this loss can be reduced to some extent. The installation for the last two

mentioned processes is rather complex and expensive. The latest patented process is the new and improved Steffen process, already introduced in a number of European factories, whose experience has verified the claims of the inventor, that by this method 90 to 92 per cent of the sugar content of the beet may be recovered in white finished product.

PROCESS OF MANUFACTURING SUGAR

The beets freed from tops and adhering dirt are delivered at the factory in wagons and cars. After being weighed and sampled they are unloaded into large storage sheds with V shaped bottoms, at the apex of which is a covered trough, extending the entire length of the shed. The trough has a movable covering and contains a stream of running water. Starting at one end of the shed, part of the covering is removed and the beets are allowed to fall into the water, which conveys them into the factory.

WASH HOUSE

Here they are carried by an elevator to the washer, which consists of a tank kept constantly full of fresh water, where they are subjected to a thorough washing by means of propeller arms, which convey them from one end of the washer to the other, keeping them constantly agitated. When thoroughly cleaned they are ejected by means of an automatic device and fall into a vertical iron bucket elevator, which carries them to the weighing machine on the fourth floor.

AUTOMATIC BEET SCALE

The beet scale is an automatic machine which weighs 700 or 1000 pounds at a time, as the case might be, and dumps them into the slicer, while at the same time the counter of the scale automatically adds up all quantities weighed and records same. No mistakes are made in calculation, and it is absolutely impossible for any of the working men to tamper with the record, the counting and adding mechanism being enclosed in a locked box.

THE SLICER

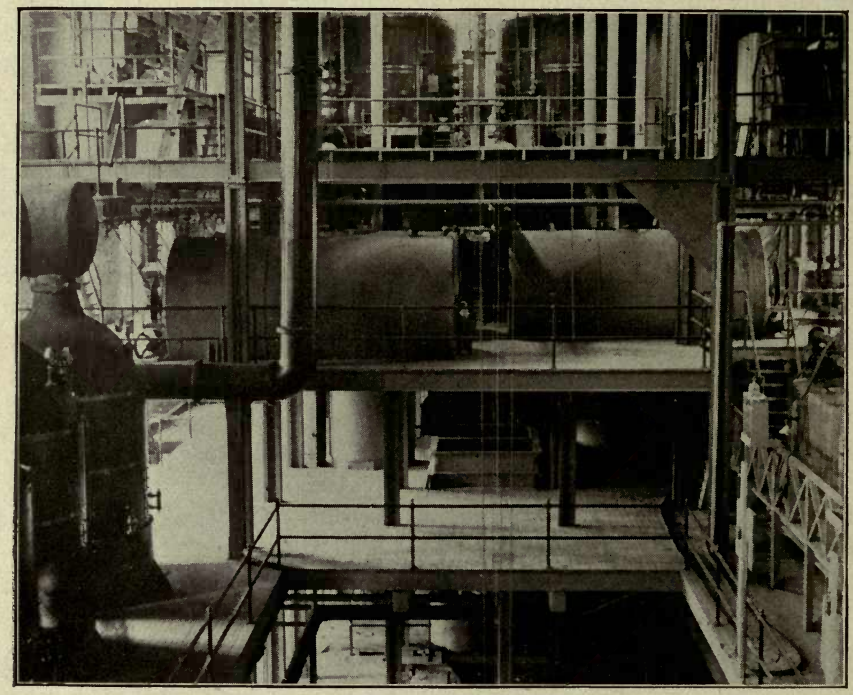
The slicer cuts the beets into triangular pieces about one-quarter of an inch wide, one-sixteenth inch thick and of greater or less length. They are cut iuto such shape to avoid their laying too closely together as to prevent the circulation of the diffusion liquors, when placed in the cells of the battery. The slicer consists of a rapidly revolving disk, about three feet in diameter, which is provided with a set of knives, cutting a large number of slices off the beets at every revolution.

DIFFUSION BATTERY

By means of a revolving chute the fresh beet slices (technically called cossettes) are conveyed into the large cylindrical closed tanks or cells of the diffusion battery on the floor below. These cells (each holding about 2 to 2½ tons) are arranged in a circle connected by piping and valves, to facilitate

filling with fresh sliced beets and discharging the pulp or slices exhausted of sugar. Each cell has adjoining it a socalled "heater" filled with brass tubes and so arranged that the juice may be heated by the admission of steam, without bringing it in contact with the juice. The cells and heaters are so connected by piping as to allow of water and juice being admitted to any individual cell or being circulated through them all. It is in the diffusion battery that the sugar held in solution in the cells of the beets is extracted.

The object of the diffusion process is to obtain sugar juice containing as few impurities as possible. As explained in a preceding chapter



MICHIGAN SUGAR COMPANY'S FACTORY, BAY CITY, MICHIGAN.
QUADRUPLE-EFFECT CRYSTALLIZER AND VACUUM.

(Structure of the Beet), the sugar is held in solution in the cells of the beet, but these cells also contain the impurities (salts, albuminoids, etc.) and whereas it is only the crystallizable bodies, that have the property of diffusing through the celltmembrane, it is desirable to have the cells remain intact and the slicer is therefore arranged to cut the beets in such a form as to rupture as few cells as possible, at the same time giving as large a surface as possible for the leaching, i. e. the action of the hot water resp. diluted juice in the operation on the diffusion battery, without preventing rapid circulation of the diffusion liquors. Care must also

be exercised to prevent bursting the cells by overheating during the process of diffusion. The temperature at which diffusion takes place is from 70° to 80° C., 158° to 176° Fah., according quality of beet.

By the methods formerly used, the beets were ground into a fine pulp. Thus the cells were torn and the entire contents of the cells, sugar as well as salts and other impurities carried into the juice, which was obtained from the pulp either by pressing by means of hydraulic presses, by maceration or by centrifrugal force. In all these methods of extracting the juice a great deal of foreign matter was obtained outside of sugar, which made the purification of the juices very difficult and hindered the manufacture.

The diffusion method now generally in use, differs from the old one in that the juice is no more separated in a mechanical, but in a purely physical way. The hot water acting upon the protoplasmic lining of the sugar cells, will allow the sugar in the cell to diffuse with the water outside, until the water outside the cell contains the same percentage of sugar as that on the inside. This water being drawn off and replaced by fresh water the same process takes place and could be continued until all the sugar had been extracted. The juice so obtained would of course be very weak, in the diffusion battery therefore the juice obtained in the first leaching is used for the second, etc.

THE PROCESS OF DIFFUSION

The operation is proceeded with as follows: First one cell is filled with fresh cossettes and hot water (at 80° C) admitted till the cell is filled. Assuming now, that the beets contain 12 per cent. of sugar, an interchange takes place, the cossettes giving up their sugar until only 6 per cent. remains, the other 6 per cent. having been taken up by the water. Meanwhile the next cell has been filled with fresh cossettes, and the water containing 6 per cent. of sugar is now forced into it, having been heated in transit to 80° C. In this second cell again an interchange takes place, but the water containing already 6 per cent. sugar, will extract but half of the difference between the sugar in it and in the cossettes; this water will now contain 9 per cent. of sugar and is forced into the third cell, where it will again absorb half the difference between its own sugar and the cossettes. The same process is continued until the water has become sufficiently rich in sugar for evaporation. In the meanwhile fresh water has again been forced into the first cell, from there into the second, and so on. When the cossettes in the first cell have become exhausted of their sugar by continued passage of fresh water, the contents are discharged through a trap door and replaced by a fresh charge. The second cell is next to be exhausted and recharged in its turn and thus every following cell continuously.

The juice now passes through the measuring tank, is accurately measured and a record taken of time, number of cell and density, and is then ready for the first carbonation.

CARBONATION PROCESS

The juice as it comes from the diffusion battery is a dark, ill-smelling liquid, when it passes into the first carbonators, large closed tanks with valves and appliances for admitting juice, lime and carbonic acid gas. Slaked lime in the form of milk of lime are introduced in the heated juice for the purpose of having the lime unite with the impurities in the juice, both chemically and mechanically. In combining with the greater part of the impurities this lime forms an insoluble precipitate, viz: carbonate of lime. The lime also combines with the sugar forming a sucrate of lime. In order to free this, in other words to separate the lime and sugar, carbonic acid gas is injected. This is done by allowing the gas to bubble through the limed juice, whereby a union of calcium and carbonic acid gas is effected, forming Calcium Carbonate. Great care must be taken not to admit more gas than is necessary to break up the combination of lime and sugar, for after this is accomplished the carbonic acid attacks other compounds of lime, and if allowed to operate too long would again set free all impurities. The process must therefore be closely watched and samples taken with a test tube every few seconds when the operation approaches completion. The gas is instantly shut off, as soon as by the formation of a granular precipitate, showing clear liquor between the particles, the completion of the process has been established.

LIME KILN

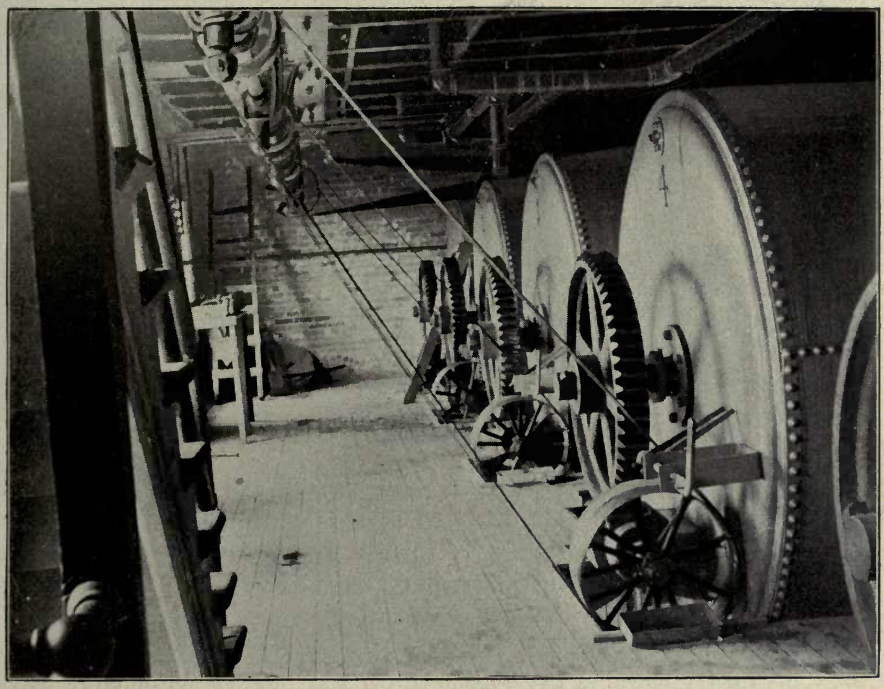
The object in burning the limestone in the factory in a specially arranged kiln, instead of buying the prepared lime, is to make sure of fresh burned lime, and furthermore to secure the carbonic acid gas, which is needed in the manufacturing process, as well as the slaked lime, as just explained.

PROCESS OF FILTRATION

The juice from the carbonators is removed and forced by means of pumps at a pressure of 60 lbs. per square inch through filter presses consisting of a series of frames and screens which remove the precipitates and other mechanical impurities. The purpose of the frame, a hollow iron square, is to receive and hold the lime precipitate. After being forced into the frames of the press, the juice passes through a finely woven cloth filter into the screen, and from there the filtered juice passes through a cock in the screen to a trough. When the frames are completely filled with lime precipitate, the flow of juice into the presses is stopped. Hot water is then forced through the presses to wash out of the lime cake and cloths any juice left, the press is then opened and the lime cake removed.

SECOND CARBONATION

The juice and the wash water from the filter presses is now passed in a second set of carbonators and submitted to the same process previously described, however very little lime if any being added. The carbonic acid gas is passed through the juice until only a trace of lime remains in it, which is determined by testing. In order to precipitate the double carbonate that may be in solution the juice is then boiled and forced through another set of filter presses.



MICHIGAN SUGAR COMPANY'S FACTORY, BAY CITY, MICHIGAN, CRYSTALLIZERS.

SULPHURING AND MECHANICAL FILTRATION

The clear strained juice from the second carbonators, which is then of a light straw color and almost pure, is now forced by pumps to the so-called "sulphiters," similarly constructed as the carbonators. By means of an air compressor sulphurous acid gas, obtained by burning sulphur in a muffle, is forced through the juice, decolorizing it and precipitating the remainder of the lime. The gas generator has two compartments, one being used at the time, so as to allow of cleaning without interrupting the process. The juice, now of a water white color, undergoes another filtering in mechanical filters (consisting of iron boxes, provided with a cover for removing the bags on the

inside) whereby any mechanical impurities which might be in the juice are removed. This process completes the purification or clarification and the now pure juice is passed to the multiple effect evaporating apparatus for the purpose of concentration.

EVAPORATOR OR QUADRUPLE EFFECT

This evaporator or so-called quadruple effect consists of four bodies, each containing two sections or chambers; the lower or steam chamber for the steam and the upper chamber, occupying about two-thirds of the space, for the juice and the vapors arising from the boiling. The upper or vapor chamber of each effect is connected with the steam chamber of the next effect, so that vapors of the boiling liquor can pass from one steam chamber to the next. The process is as follows: Steam is turned into the steam chamber of the first effect and boils the juice in that effect, the vapors arising from the steam chamber of the second effect go over and boil the juice in the third effect and so on until the boiling process goes on in all. By means of a vacuum pump attached to the condenser of the fourth effect a vacuum of different degree is created in each, and the juice can readily be drawn from one to the other. By carrying on the process under vacuum loss of sugar by excessive heat is prevented. When the juice in the last effect has reached the required point of density, it is pumped out and carried over to the vacuum pan, where it is boiled to a grain.

BOILING TO A GRAIN WITH VACUUM PAN

The vacuum pan in which the concentrated juice is boiled to a thick crystallized mass, the so-called massecuite consists of a large hollow cylinder made of cast iron put together in sections. The process of boiling is conducted as follows: By means of a pump vacuum is produced, the juice is drawn into a certain level and steam is admitted into the copper coils placed at the bottom of the pan causing the juice to boil. As soon as the juice has boiled down to a certain density small sugar grains appear, and when these have accumulated in sufficient quantity more juice is admitted. This addition instead of starting new grains, deposits upon the first. The process of admitting fresh juice and boiling down is continued until the pan is full, when it is passed into the mixer by means of a large valve situated in the bottom.

THE MIXER

This apparatus consists of a large V-shaped trough. A shaft runs through it provided with arms for the purpose of keeping the boiled juice or so-called "melada" from solidifying. This boiled juice of the appearance of a thick paste, passes to the centrifugals directly below, through short spouts, which are regulated by means of a tight fitting gate.

THE CENTRIFUGALS

A charge of boiled juice of about 200 lbs. is admitted into the centrifugals machine, which is set revolving at the rate of 1,000 revolutions per minute. At the expiration of about 10 minutes, the molasses is thrown off and the sugar adhering to the sides of the centrifugal removed. Thus the operation is completed and the pure white sugar now left, falls through a trap door situated in the bottom of the centrifugal and is taken by means of a conveyor to the dryer or granulator. The granulation consists of a circular shell provided with steam pipes that give the heat for drying. This apparatus is slowly revolving and small shelves attached to its interior sides cause the sugar to pass through its entire length without staying too long in any one part, thus preventing the danger of burning. After the slight amount of moisture is thus removed the sugar falls down a shute to a hopper and is placed in bags or barrels for shipment.

AFTER PRODUCTS

The syrup or molasses obtained from the first product as above described is collected in tanks and when a sufficient quality has accumulated, is sent back and boiled again in the vacuum pan (so-called second pan), but not boiled to a grain. When it has reached the desired consistency, it is run into crystallizers of the same capacity as the vacuum pan, which consists of large boiler-shaped vessels, supplied on the outside with a water jacket to allow of cooling when necessary. A slowly revolving shaft on the inside, provided with arms keeps the mass air in constant motion, whereby the cooling is affected. By this process a brown sugar the so-called second product is obtained.

The syrup or drains left from this operation are again sent back and reboiled in the vacuum pan, and run into crystallizers, whence they emerge as brown sugar, the so-called third product.

All this brown sugar, which is very unpalatable, is melted in a mixer and worked in with the green juice in the first pan. The molasses now left is of a very low grade and in most instances is allowed to go to the sewer or is run into the pulp. It might be used for vinegar or blacking. Some factories, when finding on analysis, that the molasses contains sugar that will crystallize, store it in tanks and let it remain there until the next season, when such sugar as has settled to the bottom is taken out and worked over. The molasses in question amounts to about 3 to 4 per cent. of the sugar content of the beet. By certain additional installations, representing different processes, such as the Osmose, Ransom, Strontian processes, Steffen and others, part of the sugar can be recoverd.

PULP

A vexing problem which has confronted many factories in the past was, what to do with the pulp, which amounts to about 50 per cent. of the tonnage of beets worked up in a factory. Our farmers are just now beginning to appreciate the value of this pulp as a stock

food. Experiments along the line have shown that for fattening hogs and cattle, feeding lambs and the dairy cow, this pulp offers a valuable and cheap food. At one dollar a ton it would be cheap, and in such parts of the country where there are large dairy or stock feeding industries the factories have found no difficulty of disposing of the pulp at from 35 cents to $1.00 per ton, the farmers furnishing the beets to the factory as a rule being glad to take such share as represented by the total of their beet deliveries at an agreed upon price to be deducted from the price they received for the beets. This pulp may be siloed with a sprinkling of salt and loses none of its virtue for a couple of years after it is siloed. It has been claimed on basis of tests that better results are obtained from siloed pulp than from the fresh pulp, *i. e.* when fed coming direct from the mill; furthermore that such pulp fed to cattle makes a firmer, tenderer and better colored beef. The value for the dairy may be better understood from the following figures: Calculating the value on a basis of units of feeding value, allowing three units for proteine, two units for fatty substances and one unit for substances free from nitrogen, this pulp would represent 44 units of feeding value.

COST OF A BEET ROOT SUGAR FACTORY

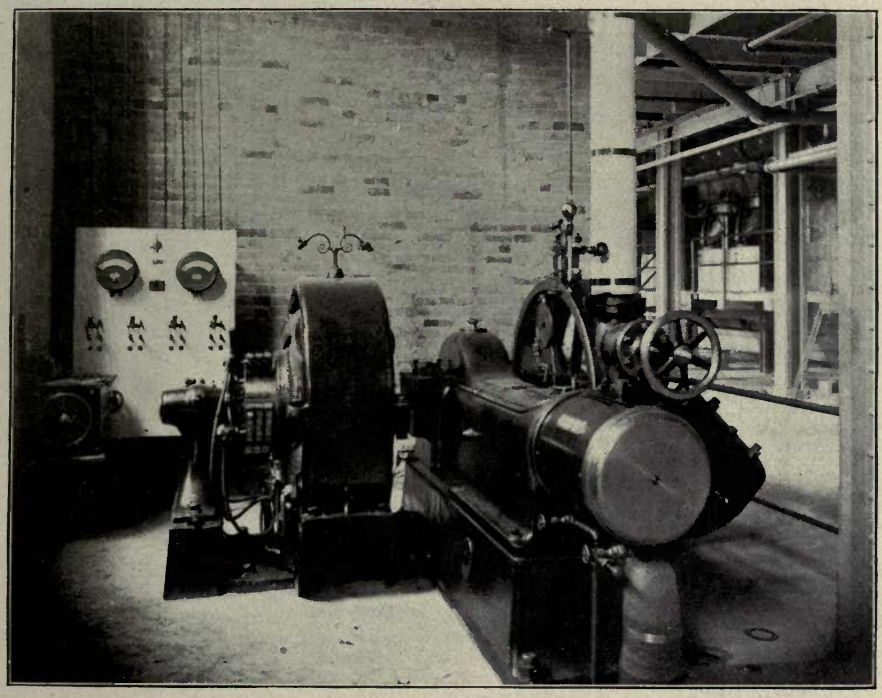
It is impossible to give anything more than a rough estimate of the cost of building, equipping and operating a beet sugar factory, applicable to all sections of our country. In the previous chapter we have already mentioned the main requisites or conditions necessary for the success of a factory, such as materials, labor, etc. All these conditions, which of course vary widely in different parts of the country, govern the cost of the plant in the first place. Then it would depend to some extent on the character of the buildings, whether fire proof or part fire proof, or not, the capacity of the house, etc.

Approximately the cost of a sugar house of a capacity of not less than 350 tons, will amount to $1,000 for each ton of daily capacity, in other word a factory of 350 tons capacity would cost about $350,000. At less than 300 tons capacity the cost would exceed the $1,000 per ton.

The Fred. W. Wolf Co. will be glad at any time to give closely figured estimates for erecting factories in any part of the United States after having investigated the location. We frequently have occasion to reply to inquiries from people who are under the impression that with an old building, a second-hand boiler and engine and worn out apparatus and appliances that have been used for other purposes, they have a good nucleus for a beet sugar factory, and that with a comparatively small additional outlay such a plant would give satisfactory results. There is no more mistaken notion than this. Any attempt of this kind is in our opinion simply that much money thrown away. Not one of the various enterprizes that were started on such a basis but proved a deplorable failure.

An old building might possibly be adapted to sugar factory purposes but the small saving in the first cost would likely soon be eaten up by the increased expense of operating such a plant, resulting from the necessity of adapting the arrangement of the apparatus to the structure. In order to build economically and insure profitable operation a sugar factory must be built with this special purpose in view.

A priori we want to say, and in the most emphatic manner, that it would be rank foolishnes to go in the beet sugar business without ample means to erect a factory of proper size as well as of the most modern construction both as regards building and machinery.



MICHIGAN SUGAR COMPANY'S FACTORY, BAY CITY, MICHIGAN.
ELECTRIC PLANT.

COST OF SUGAR AND PROFIT CALCULATION

The cost of the sugar and the profit to the factory depend on the conditions already partly discussed under the heading "Factory requirement," the amount of material used, price of beets and wages paid. Fuel, limestone and wages are the three principal expense items in a sugar factory, and run about as follows per ton of beets:

	Cents per ton of Beets.
Coal (basis 8-fold evaporating power) 12 per cent., at $3 00 per ton, . . .	36
Limestone (basis 95 per cent. of pure lime) 10 per cent., at $1.60 per ton, .	16
Wages (basis full season of 100 days) 160 hands at $2 50 average wages, .	80

In a factory of a daily capacity of 500 tons, where coal or limestone or wages would be 25 or 50 per cent. higher, the expenses during a season would be increased in the following amounts:

	25 per Cent	50 per Cent.
Coal,	$ 4,500	$ 9,000
Limestone,	2,000	4,000
Wages,	10,000	20,000

A difference of 1½ per cent in the quality of the beets, that is to say, the real outturn of granulated would make a difference of ten pounds of sugar per ton of beets, or (on basis of a price of 5 cents per pound) $25,000 per season.

From this it will readily be seen that the factor which mainly determines the cost of the sugar is a full supply of beets of good quality. The total daily average expenses per ton of beets may be calculated as follows:

	Per Ton of Beets.	
Beets, at $4.00 per ton	$4.00	
Coal, 12% at $3.00 per ton	.36	
Limestone, 10% at $1.60 per ton	.16	
Wages, at $2.50	.80	
Coke and other materials, such as chemicals, lubricants, etc.	.75	
	$6.07	
Making for 50,000 tons worked up in a season of 100 days	$303,500	
To which would have to be added the general or annual expenses for office, selling and travelling expenses, insurance, repairs, stationary and incidentals, in round figures	50,000	
Total	$353,500	
On an outturn of say 10%, or 10,000,000 pounds of granulated the factory would receive at an average net price of 5 cents per pound	$500,000	
Adding to this the value of pulp and molasses at say, 50 cents per ton	25,000	
Total receipts would amount to		$525,000
Less total expense as above		353,500
Profit		$171,500

The following tables will show the profits per season, also the difference in cost per pound of granulated sugar, according to yield and quantity.

Yield per ton, Beets	7½%=150 lbs.		8%=160 lbs.		8½%=170 lbs.		9%=180 lbs.		9½%=190 lbs.	
Tons of Beets worked per Season	Cost of 1 lb. Granulated.	Profit per Season.	Cost of 1 lb. Granulated.	Profit per Season.	Cost of 1 lb. Granulated.	Profit per Season.	Cost of 1 lb. Granulated.	Profit per Season.	Cost of 1 lb. Granulated.	Profit per Season.
	Cents.	Dollars.	Cents.	Dollars.	Cents.	Dollars.	Cents.	Dollars.	Cents.	Dollars.
350	4.67	17.550	4.38	35.050	4.12	52.550	3.89	70.050	3.70	87.550
400	4.55	27.200	4.26	47.200	4.01	67.200	3.79	87.200	3.60	107.200
450	4.45	36.850	4.17	59.350	3.93	81.850	3.73	104.350	3.52	126.850
500	4.38	46.500	4.11	71.500	3.86	96.500	3.65	121.500	3.45	146.500
550	4.32	56.150	4.05	83.650	3.81	111.150	3.59	138.650	3.40	166.150
600	4.27	65.800	4.00	95.800	3.76	125.800	3.54	155.800	3.37	185.800
650	4.22	75.450	3.96	107.950	3.73	140.450	3.52	172.950	3.34	205.450
700	4.19	85.100	3.92	120.100	3.70	155.100	3.49	190.100	3.30	225.100
750	4.16	94.750	3.89	132.250	3.67	169.750	3.46	207.250	3.28	244.750
800	4.13	104.400	3.87	144.400	3.64	184.400	3.44	224.400	3.26	264.400
850	4.11	114.050	3.85	156.550	3.62	199.050	3.42	241.550	3.24	284.050
900	4.08	123.700	3.82	168.700	3.60	213.700	3.40	258 700	3.23	303.700
950	4.06	133.350	3.81	180.850	3.58	228.350	3.38	275.850	3.21	323.350
1000	4.04	143.000	3.80	193.000	3.57	243.000	3.37	293.000	3.20	343.000
1050	4.03	152.650	3.78	205.150	3.56	257.650	3.36	310.150	3.19	362.650
1100	4.01	162.300	3.76	217.300	3.55	272.300	3.35	327.300	3.17	382.300
1150	4.00	171.950	3.75	229.450	3.54	286.950	3.34	344.450	3.16	401.950
1200	3.99	181.600	3.74	241.600	3.52	301.600	3.33	361.600	3.15	421.600
1250	3.98	191.250	3.73	253.750	3.51	316.250	3.32	378.750	3.14	441.250
1300	3.97	200.900	3.72	265.900	3.50	330.900	3.31	395.900	3.13	460.900
1400	3.95	220.200	3.70	290.200	3.48	360.200	3.30	430.200	3.12	500.200
1500	3.93	239.500	3.69	314.500	3.47	389.500	3.28	464.500	3.11	539.500
1600	3.92	258.800	3.68	338.800	3.46	418.800	3.27	498.800	3.10	578.800
1700	3.91	278.100	3.67	363.100	3.45	448.100	3.26	533.100	3.09	618.100
1800	3.90	297.400	3.66	387.400	3.44	477.400	3.25	567.400	3.08	657.400
1900	3.89	316.700	3.65	411.700	3.43	506.700	3.24	601.700	3.07	696.700
2000	3.88	336.000	3.64	436.000	3.42	536.000	3.23	636.000	3.06	736.000

Yield per ton, Beets	10%=200 lbs.		10½%=210 lbs.		11%=220 lbs.		11½%=230 lbs.		12%=240 lbs.	
Tons of Beets worked per Season	Cost of 1 lb. Granulated.	Profit per Season.	Cost of 1 lb. Granulated.	Profit per Season.	Cost of 1 lb. Granulated.	Profit per Season.	Cost of 1 lb. Granulated.	Profit per Season.	Cost of 1 lb. Granulated.	Profit per Season.
	Cents.	Dollars.	Cents.	Dollars.	Cents.	Dollars.	Cents.	Dollars.	Cents.	Dollars.
350	3.50	105.050	3.34	122.550	3.20	140.050	3.04	157.550	2.92	175.050
400	3.41	127.200	3.25	147.200	3.10	167.200	2.95	187.200	2.84	207.200
450	3.34	149.350	3.19	171.850	3.03	194.350	2.90	216.850	2.78	239.350
500	3.29	171.500	3.14	196.500	2.99	221.500	2.86	246.500	2.74	271.500
550	3.24	193.650	3.09	221.150	2.95	248.650	2.82	276.150	2.71	303.650
600	3.20	215.800	3.05	245.800	2.91	275.800	2.78	305.800	2.67	335.800
650	3.17	237.950	3.02	270.450	2.88	302.950	2.76	335.450	2.64	367.950
700	3.14	260.100	2.99	295.100	2.86	330.100	2.74	365.100	2.62	400.100
750	3.12	282.250	2.97	319.750	2.84	357.250	2.72	394.750	2.60	432.250
800	3.10	304.400	2.95	344.400	2.82	384.400	2.70	424.400	2.58	464.400
850	3.08	326.550	2.93	369.050	2.80	411.550	2.68	454.050	2.56	496.550
900	3.06	348.700	2.92	393.700	2 78	438.700	2.66	483.700	2.55	528.700
950	3.05	370.850	2.90	418.350	2.77	465.850	2.65	513.350	2.54	560.850
1000	3.04	393.000	2.89	443.000	2.76	493.000	2.64	543.000	2.53	593.000
1050	3.02	415.150	2.88	467.650	2.75	520.150	2.63	572.650	2.52	625.150
1100	3.01	437.300	2.87	492.300	2.74	547.300	2.62	602.300	2.51	657.300
1150	3.00	459.450	2.86	516.950	2.73	574.450	2.61	631.950	2.50	689.450
1200	2.99	481.600	2.85	541.600	2.72	601.600	2.60	661.600	2.49	721.600
1250	2.98	503.750	2.84	566.250	2.71	628.750	2.59	691.250	2.49	753.750
1300	2.98	525.900	2.83	590.900	2.70	655.900	2.59	720.900	2.48	785.900
1400	2.96	570.200	2.83	640.200	2.69	710.200	2.58	780.200	2.47	850.200
1500	2.95	614.500	2.82	689.500	2.68	764.500	2.57	839.500	2.46	914.500
1600	2.94	658.800	2.81	738.800	2.67	818.800	2.56	898.800	2.45	978.800
1700	2.93	703.100	2.80	788.100	2.67	873.100	2.56	958 100	2.45	1,043.100
1800	2.92	747.400	2.79	837.400	2.66	927.400	2.55	1,017.400	2.44	1,107.400
1900	2.92	791.700	2.78	886.700	2.66	981.700	2.54	1,076.700	2.43	1,171.700
2000	2.91	836.000	2.77	936.000	2.65	1,036.000	2.53	1,136.000	2.42	1,236.000

In all of the foregoing calculations the general expenses have been calculated at $50,000 regardless of the quantity of beets worked per season, for the reason that this expense item does not fluctuate to any extent in relation to the quantity of beets.

The value of the residue in pulps and molasses viz: 1200 lbs. of pulp and 20 lbs. of molasses, has been calculated at 50 cents per ton of beets, which is considerable less than actual value, as shown in previous chapters.

The price of beets, $4.00 per ton, represents the average price generally paid by our factories. The other daily expense items for materials and labor, will in most cases be found below our figures.

The price of coal varies greatly in the different states, but the figure of $3.00, taken as basis for our calculation, is rather above the average. The amount of coal consumed is by far a more important factor than the price of coal. As already referred to in a previous chapter, in modern European factories 75 lbs. of steam per 100 lbs. granulated is not an unfrequent figure. This means that with coal of 7,000 to 7,500 calories or about eight fold evaporating power, the consumption amounts to only about 9 per cent. coal per ton of beets.

Hence, if as has been the case in some factories in this country, 23 per cent. of coal are used, this means a difference of 14 per cent. or 7,000 tons; in other words, at $3.00 per ton, $21,000 worth of coal would be needlessly burned up. This difference amounts to 21/100, or say 1/5 cent for pound of granulated sugar just for the item "Coal." It will therefore be seen, that the amount of coal consumed cuts a much more important figure, than the factor "price of coal," since an increase in the price of coal of $1.00 per ton, would increase the cost of production only 6/1000 cent per lb. granulated.

Of course just as much depends on the quality of the coal, than the boiler plant and evaporating apparatus, and last, but not least, the way they are run.

As regards wages, the figure of $2.50, taken as average wages, is certainly higher than in most localities. Every quarter of a dollar more or less in average wages represents an additional or reduced expenditure of $4,000 for season, or $\frac{4}{100}$ cent per pound of granulated sugar.

From the foregoing tables it will be seen, that a factory working up annually 50,000 tons of beets, yielding 200 pounds of granulated sugar from each ton of beets, can produce such white granulated sugar at a cost of 3.29 cents per lb. There are factories in the U. S. who have obtained 240 lbs. and even more of sugar from each ton of beets, because the beets were exceptionally rich in sugar and furthermore owing to expert and competent management.

In some states a bounty is granted to the beet sugar factories which of course correspondingly increases the profit. But as the foregoing

figures and the experience of the factories in such states as have no bounty law conclusively proves, the beet sugar industry is not dependent on such state aid, which at best can only by temporary.

CONCLUDING REMARKS

A discussion of the subject of these pages from a national economic standpoint would lead beyond their scope. We have already alluded to the large profits accruing to the farming, dairy and meat interests, the manufacturers, the capitalists and all the trades directly and indirectly benefited by the culture of beets and the manufacture of sugar, likewise to the effect of the industry on land values. The following, showing the average disbursements of a 500-tons capacity beet sugar factory during one season, illustrates the importance of the industry:

Amount paid to the farmers for beets	$200,000
Freight paid by farmers to R. R. companies	15,000
Freight paid by factories to R. R. companies	30,000
Coal	18,000
Limestone	8,000
Coke and other materials	37,500
Wages	40,000
Salaries, commission for selling and other expenses	50,000

In conclusion we repeat, that wherever beets of good quality, say testing 12 per cent. of sugar, with a purity co-efficient of 75 per cent. and upward can be raised in sufficient quantities, it will pay well to erect factories. The advantages which must accrue to the farmer as well as to the factory owners, as set forth in the preceding pages are so obvious, that it is to be hoped and expected, that the industry will make rapid progress in our country in the near future.

FINIS.

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Press Comments.

On Factories Built by the Fred W. Wolf Co.

From a correspondent in Michigan the PLANTER learns that the Michigan Sugar Co., at Bay City, Mich., started its second campaign October 4, and that of the nine factories in operation in Michigan this year *the Michigan Sugar Co. has the distinction of being the first to make sugar.* Our correspondent says further that the daily capacity of the factory has been enlarged to 500 tons and that an exceptionally successful campaign is anticipated. Some of the new factories will have but a short run on account of the scarcity of beets.—*Louisiana Planter Oct. 14, 1899.*

The beet sugar factory which is located here and is just completed by the contractors, Messrs. Fred W. Wolf & Co., of Chicago, for the Oakland Sugar Company, is about to begin operation. All of the machinery is up and testing it with steam is now going on. The masons and concrete contractors still have some work to do, but by the 26th of October everything will be ready, and that is the day set to commence operations.

The factory as it stands comprises a four-story building of brick and steel, with arched concrete flooring, three beet sheds 400 feet long and 90 feet wide, all under one roof.

The machinery will have a capacity of about 500 tons of beets per day and comprises two beet washers, two cutters and a battery of 14 cells, each holding 2¾ tons of beets, eight carbonating tanks, two lime kilns, 10 filter presses of 900 square feet of filtering surface each, two sulphur boxes, 10 mechanical filter presses, one quadruple effect of the standard style with 5,000 square feet of heating surface in each pan, two vaccuum pans 11 feet each in diameter, 14 crystallizers, each holding 864 cubic feet of masse cuite, or the contents of the pan, 10 forty-inch centrifugal machines, one granulator, shakers and conveyors, six upright boilers of 250 horse power each, with Dutch ovens in front, two Corliss engines of 200 horse power each will supply all the power needed.

All the machinery, with the exception of the boilers, pans, multiple effects, centrifugals and pumps were made in Chicago by the contractor. The pumps are all of the Marsh make of Battle Creek, Mich.—*Rochester Correspondence of the Louisiana Planter Oct. 16, 1899.*

The first strike of sugar was made Sunday and another to-day, which classed as first class granulated sugar, something unusual for a new factory to do, as invariably the first strikes are melted up again, being full of specks and of off color.—Rochester Correspondence of the Louisiana Planter Nov. 5, 1899.

Representatives of THE MICHIGAN SUGAR BEET, through the courtesy of President Cranage, and piloted by Mr. Sam Cranage, paid the pioneer institution a visit during the week and witnessed this grand transformation.

The company is receiving on an average 200 loads of beets per day, averaging 500 tons, and is paying out to the farmers about $2,500 per day. The crop for this company, which is the first to receive beets, is averaging 12 tons per acre, and the price paid is in the neighborhood of $4.75 per ton, a little better than the average for last season. While the tonnage is somewhat less than that of last season, the sugar content is about 2 per cent. higher, which gives the farmer about as much as he received last season for his crop. . . . . .

Up to the time of our visit the factory had turned out 3 carloads of sugar each day it had been in operation, and the products had found ready sale.

At the Michigan factory about 125 men are employed, and 70 tons of Bay county coal consumed each day.

The company has 4,200 acres under contract, and will pay out nearly $250,000 to farmers. This company's contracts are very largely, this season, with the farmers of Bay county.

A new office and storeroom are about completed. The office will be very complete, and is of attractive architectural design and will be arranged in the most convenient form.

President Cranage anticipates a most successful campaign, and judging from the manner in which his contractors are being treated, and express themselves, the company will be obliged to turn a deaf ear to many who will seek contracts when the books are opened for another season.—*Michigan Sugar Beet, Nov. 3, 1899.*

The factory of the Michigan Sugar Company at Bay City is running along smoothly, consuming 500 tons of beets per day, and with a daily output of three carloads of high grade sugars. Owing to the higher sugar content of the beets this year, the company is paying about $4.75 per ton of beets, against $4.50 last year, but the increase in price to the farmers is offset by a reduced tonnage.—*Louisiana Planter, Nov. 14, 1899.*

Few if any lines of domestic industry are more promising than that of the beet sugar factories, which are springing up in all parts of the West. They cost from $250,000 to a considerably higher amount and the amount of machinery that is required to equip a plant of this kind is enormous. It is giving to the machinery men one of their present best markets.

Many people have never seen one of these large new American industries. The beet sugar factory which has recently been erected by the Oakland Sugar Mills Company at Rochester, Mich., *is perhaps the best equipped beet sugar factory in the country* and the designers, architects

and builders are the Fred W. Wolf Company, 139-143 Rees street, Chicago, who are also just completing a 500-ton beet sugar factory for the Kalamazoo Sugar Company, Kalamazoo, Mich., which is almost an exact duplicate of the Rochester plant.

The Fred W. Wolf Company has just completed improvements on their shop, consisting of a new erecting and machine shop, and pattern, storage, warehouse and office addition, thereby more than doubling their 1898 capacity. The company is enjoying a rushing trade with an outlook for an exceedingly prosperous new year's business. In the ice machine business the company has recently received a large number of orders.—*Iron and Steel, November, 1899.*

Saturday afternoon the first beets began their journey from the sheds into the Kalamazoo factory.

It was the signal for the starting of the entire plant, which will be continued in operation until the campaign is ended.

The actual starting was witnessed by a number of officers and stockholders. Sunday morning half of the entire plant was in operation. Beets were sent in a practically continuous stream into the factory, through the washer and thence up the elevator, through the automatic scale, to the grinding machine, and finally to fall into the diffusion battery.

All was activity and bustle. The experts were at their respective stations directing the movements of the laborers and watching the operation of the machinery. The officers watched it all closely and everybody congratulated everybody else on the successful starting of the big factory.

During the forenoon the juice from the diffusion battery was sent through the various processes. The chemists with their testing tubes watched the liquid sugar in its various states.

Tuesday the management expected that the product of the beets would be sent through the entire plant, when the white sugar would fall in a stream from the last machine.

An officer says that a ready market will be found for every pound of sugar turned out. "In fact," said he, "we could have sold twice the capacity of the plant even at this time."

"Everything worked smoothly at the plant," said Treasurer Henry this morning. "We had to start the machinery gradually, in order to see that every separate piece is in good order. This first sugar may, however, be off color, compelling the men to send it through again. But as soon as the men get all in good order, the sugar will be as fine as any."

Mr. Henry could not say as to how long the campaign will last. He said that beets are coming in every day, and many car loads are expected to arrive for many days to come. Southern Michigan soil has proven its superiority as a beet producer.—*Michigan Sugar Beet, December 1, 1899.*

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